THE MESSENGER

EL MENSAJERO

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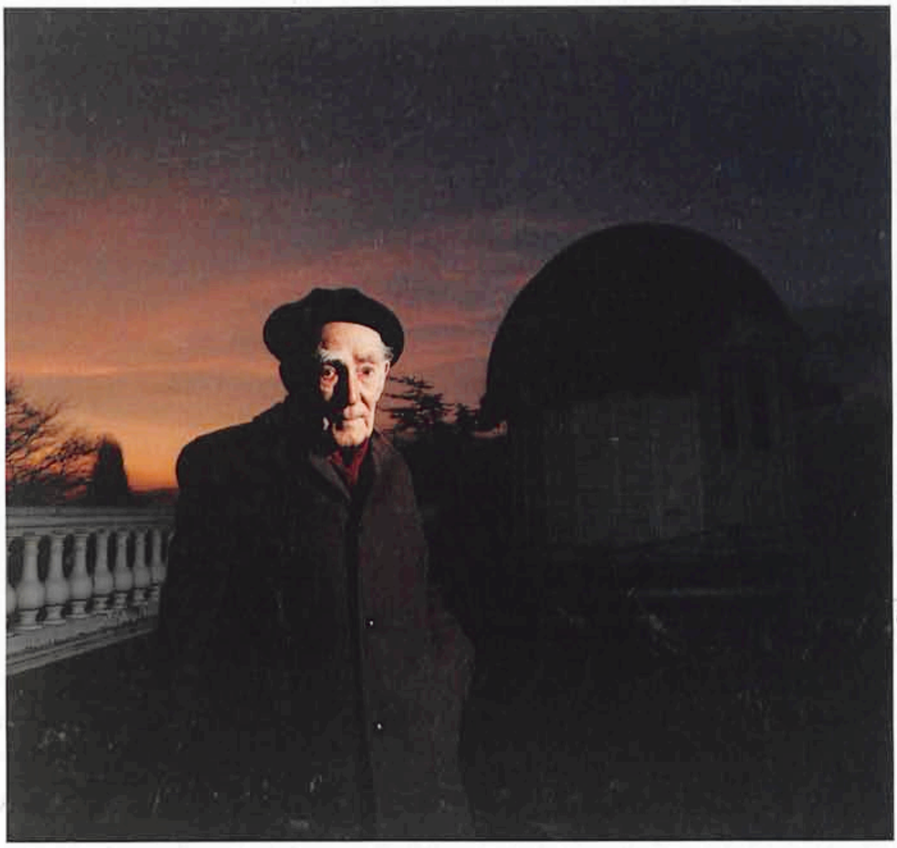
Jan Hendrik OORT (1900–1992) – Looking Ahead in Wonder

The life of the man I think of as this century's greatest astronomer ended on 5 November 1992, a life long, rich, full of arduous labour and marvellous results. Without Jan Oort, ESO would not have begun when it did, indeed without him ESO might never have been. Yet our Organization's birth is but one of his many achievements and as we gratefully remember him, his life is an inspiration unparaleled in our science, an epoch-making journey of our time.

At Leiden Observatory – de Sterrewacht de Leiden – which was Oort's base for most of his professional endeavours, a careful compilation of his writings, including notes and correspondence, has been prepared and recently published, the archive deposited with the Leiden University Library, readily accessible for historical research. In 1980 friends and colleagues wrote a book, a *liber amicorum* for and about him, called *OORT and the UNIVERSE*. Shortly thereafter Oort himself wrote one of his scarce autobiographical papers which appeared in the series "My life as an Astronomer", in the 1981 issue of *Annual Reviews of Astronomy and Astrophysics*. A fascinating biography remains to be written.

Professor Oort managed in some inimitable way to combine his teaching and research in the university context with policy making, programme development and organizational actions on both the national and international scenes. His research spans seven decades: from his first paper, in 1922, entitled "Some peculiarities in the motion of stars of high velocities" to the last one I found (*MERCURY*, March/April 1992), on "Exploring the Nuclei of Galaxies (Including our Own)". Oort normally dealt with major themes that he pursued for



J.-H. Oort at the Leiden Observatory, January 1992. *Photo: Bert Janssen* years or even decades and to which he contributed insights which have often become authoritative standards in our science, sometimes the commonly shared features of mankind's worldview. Of the former I remember the influence I experienced of his classic paper with Walraven on the Crab Nebula in 1956. The latter certainly is the case for both the rotation of the Galaxy and the origin of comets. He was often decades ahead of his time, was for example lecturing on dark matter in 1926 . . .

Oort cannot be called an observational astronomer, but neither was he a theoretician. He could be more sceptical of clever theories than of even the shakiest of observations (at least if the latter fitted his intuitive expectations), his theoretical work was driven and directed by empirical evidence, by observations, by the phenomena for which he had an insatiable appetite. He was the *interpretive* astronomer *par excellence*, able always to discern features in maps and in other data sets which those who had so diligently acquired them had overlooked, could oft barely distinguish even when he pointed them out. One of the reasons he interacted so intensely with such an inordinate number and variety of astronomers, in conversation, in discussions, in correspondence, was surely his overwhelming interest in astronomical data, his contageous enthusiasm for observational discoveries and his impatience with the construction of new facilities. The last time I spoke to him he praised the NTT for the SHARP pictures of the Galactic Centre (referred to in his last article) and wanted a progress report on the VLT from which, especially in its interferometric mode, he expected wonders.

In the Netherlands Oort was the driving force and the guiding spirit of the team which from the simplest beginning with the Wurzburg dish at Kootwijk, via the Dwingeloo Telescope to the sophistication of the Synthesis Radio Telescope at Westerbork brought radio astronomy to its uncontested observational maturity in thirty years of unrivalled progress. While elsewhere radio engineers and physicists started and operated radio observatories, in Holland an astronomer from the start determined the observing programmes, the technical priorities and the next telescope's configuration. As a result the Dutch school of astronomy, perhaps before any other, became problem- rather than technique-oriented, working on astronomical themes and using whatever technique was available, in whatever wavelength region, as long as it contributed to insight in the problems astronomically posed and astrophysically interpreted. It is this approach which caused Oort also to take major initiatives in Dutch space research.

Oort was in spirit and actions a world citizen. Aided by his fluency in four languages, he worked towards international collaborations, exchange and astronomical pooling of resources throughout his career. It was his fate, and the world community's good fortune that he was Secretary General of the International Astronomical Union in 1938. He held this office for a decade, carrying the IAU through those awful times with persistence, loyalty and the conviction that astronomy defies ideology and is a precious human endeavour. Unlike ESO's, I know of no written account for the development of the IAU; it will be very interesting to learn what its archives can reveal of this period in IAU history.

Adriaan Blaauw's book "ESO's Early History" has an index where Oort's name stands out by its long list of page references. More than quantity though, it is the substance of Oort's contributions to ESO which is vital and unique. An idea conceived at Leiden in discussions between Walter Baade and Jan Oort in 1953, it took ten years to bring it to first fruition, marked by the signatory ceremony of the ESO Convention in Paris on 5 October 1962. In the interval this splendid idea of ESO was threatened numerous times and it was the tenacity of Oort, who untiringly used his linguistically supported diplomatic skills, which ensured that the future remained open. Thanks in large measure to him, astronomy in Europe today possesses the exciting prospects to which this quarterly testifies each issue.

Overviewing Oort's scientific achievements and the size of his oeuvre, one is awed by the creativity of his long life. But assessing his organizational and policy accomplishments is an equally amazing experience. That one man should take several major initiatives and then lead such a large fraction to successful maturity is scarcely imaginable. The combination stands out as towering productivity and unstinting devotion. To think however that this must have been a workaholic's life, neglectful of family and friends, is belied by all of us who knew him from close range. His family life was rich, as movingly attested by a son and a granddaughter at the memorial gathering on 10 November. Mieke and Jan were frequent and warmly attentive hosts to innumerable tea- and dinner guests. Those who discussed literary works with Jan, rowed with him or skated through the wintry polder landscape north of Leiden know how broad his interests and how varied his excertions were.

Nevertheless, things astronomical were predominant in his life, especially the latest things and the things to come. The phrase in the heading of this In Memoriam is the title Oort wrote he would have given to the autobiography he did not write. He was forever curious about the latest results from telescopes, any telescope, he lived in anticipation of data to come, he hungered for perspectives in regions where his mind sought to penetrate; he died, as a well-known Dutch weekly headlined its obituary, "with a head full of questions".

The Oort family, in the official announcement of their husband's father's, grandfather's and greatgrandfather's death, cite from Loren Eiseley's "Immense Journey" a passage so quintessentially focussing his life that I repeat it here:

"Down how many roads among the stars must man propel himself in search of the final secret! The journey is difficult, immense, at times impossible, yet that will not deter some of us from attempting it . . .; we will travel as far as we can, but we cannot in one lifetime see all that we would like to see or learn all that we hunger to know."

It was our privilege to know Jan Hendrik Oort, to learn from him as we traveled far with him. It is our privilege to continue his journey.

H. VAN DER LAAN

ANNOUNCEMENT

2nd Miniworkshop on Large CCDs

is planned for October 4–5, 1993 at the ESO Headquarters in Garching. As it was the case for the workshop held in June 1991, ESO solicits the participation of the groups in Europe who are active in this field and will secure the attendance of a few selected experts from overseas. We expect also presentations by the companies which are involved in the production of CCDs for astronomy.

Topics to be discussed are design, manufacturing and characterization of large-size CCDs, plans for future devices, control systems and developments related to data preprocessing and data compression.

If you are interested in future announcements, please contact:

O. Iwert – CCD Workshop
Telefax 49-89-3202362
E-Mail: oiwert@eso.org (Internet)

The Idea of the European Southern Observatory

HARRY VAN DER LAAN, ESO's 4th Director General

ESO's Mission

Five years, twenty issues of the *Messenger* later, I take this opportunity to denote my attitude towards our Organization, my understanding of its mission, which has consistently guided my actions the years I have held this office and excercised its responsibilities. This is not the time to comprehensively summarize the achievements and disappointments, which can in any case be culled from Annual Reports and from five years of *Messengers* by perceptive readers.

For me ESO is the embodiment of an idea, conceived in Leiden by Oort and Baade in 1953 and developed in interaction by a small group of leading European astronomers and a few farsighted administrators from then till ESO's birth in October 1962. The essence of this idea is to promote astronomical research in the community comprised of the astronomers in the member States. That mission has many facets, the foremost task being the construction and operation of world class observing facilities for the users from the community. Derivative tasks are evident: to exploit the facilities so provided to the full, requires a community that is competent, ambitious, interactive, collaborative and competitive.

To stimulate these characteristics a host of activities can be thought of and indeed have been deployed: workshops, conferences, summer schools, fellowships, technical panels and subdisciplinary working groups, telescope advisory committees. These are ways and means to achieve interaction between ESO and its community and among community constituents, across boundaries of nations, languages, traditions and subdisciplines. This mission sums up to ESO's central characteristic, namely that of a European astronomy service organization. To further develop the quality of this mission I have initiated numerous measures which are now operational. I mention some highlights.

Astronomy on La Silla

On La Silla the astronomy group was revitalized under new leadership, with improved facilities and with an increase of youthful team members, as the Astronomy Support Department. The ASD has organized itself to cope with the introduction and assistance of a growing number of visiting astronomers who come to use a large suite of ever more sensitive, flexible but more complex equipment. ASD members are themselves active observers, compete as do community members for observing time in the OPC. There are many collaborations among them and with community colleagues, they have an active scientific life, with weekly internal research presentations and frequent colloquia by visitors. Young people circulate between the community and the ASD, spending one or two years as students/cooperants or up to three as fellows on the mountain, all with service tasks and research in combination. Returning to the community, they enhance the connectivity with ESO of the institutes they join.

Activities in the Science Division

This is equally true for the fellows and students appointed to the Astronomy Group of the Science Division. For them the service tasks are more modest and they have many opportunities for collaborative connections with ESO staff and with visitors to the Science Division. That visitors' programme has been enlarged the past two years, in both Image Processing Group and Astronomy Group. Although as a science service organization ESO's in-house research is a secondary objective, meant to enhance the prime objective, by having critical users in house directly interacting with other staff and carrying out part of the service functions themselves, the in-house research is nevertheless very extensive. At the present time some seventy-five scientists who do research part time or full time, including paid visitors, are employed by ESO. Fully half of all astronomy publications based on or related to La Silla observations and other ESO services, have at least one author who is on the ESO payroll!

Our image processing system MIDAS has been drastically improved in these years and is now installed at more than 150 institutes. Ways have been developed to enable community users to contribute to MIDAS utilities by paid residence periods in Garching. MIDAS will be the VLT's data handling system and is finding its way into La Silla domes now. The La Silla ASD team is actively contributing to the system. With the stimulus of VLT standardization and the ubiquity of powerful workstations, MIDAS will serve European astronomers in the long term, also where institutes use several systems side by side.

Key Programmes

To counter trends of increasing research fragmentation and, positively, to promote inter-institutional and multinational collaborations for ambitious strategic goals, the idea of Key Programmes was defined, implemented and tuned. Some two dozen KPs, involving more than two hundred astronomers in all member States as well as from many other countries are now running, typically for three to five years. The past sixteen or so issues of this journal have seen profiles of these programmes, in order to acquaint the community at large with the work in progress, information which itself has influenced the direction of normal programmes and sometimes led to enlargement of the KP teams.

Action in the VLT Division

In the VLT Division the past five years have been turbulent, very full with new technology and with the learning process of working on the preparation and execution of many institutional and industrial contracts at once. At the same time, but after commissioning of the NTT largely in the context of VLT preparatory activities, work for La Silla continued. I mention the development of adaptive optics, in a major collaboration with several French institutions and of remote control systems, in collaboration with Trieste. All this in addition to the continual delivery of ever improving optical and infrared array detectors and associated cameras.

The VLT programme itself is now nearing the halfway mark, both in time and in the resources contractually committed. The work of the Division is rapidly shifting from tendering preparations to contracts executions. The tendering process has been very professionally standardized and ESO has engaged many industries in a remarkably extensive set of R & D contracts and preliminary enquiries as preludes to that process. An aspect of ESO's mission is to further technology development in European industry, a task systematically developed over the past ten and more years.

Instrumentation Plan, VLTI and the Community

A quite new aspect of ESO interfacing with the community has been the development of both the VLT instrumentation plan and of VLT Interferometry. Both were defined with the intense participation of a community Instrumentation Panel and an Interferometry Panel. New ways of collaborating, based on contractual arrangements adapted to the new circumstances, were outlined, discussed and implemented step by step. I consider these contracts, which greatly multiply ESO material and human resources by highly skilled human resources from the community, as a major and successful innovation. For the Instrumentation Plan it is already far on the way with a number of contracts, both for predesign and for design and construction work, signed and in progress. For VLTI all preliminary work is complete, the Interferometry Panel has completed its work, its final report is in press and contracts with industry and with community institutes consortia are in preparation. VLTI promises to be on the cutting edge of the VLT Observatory's exploration of new domains in parameter space, with community staff playing a dominant role in the venture.

The VLT programme scientist is a key figure guarding the science objectives of the programme as he monitors all VLT Division activities. A particular set of activities form the formation and conduct of Instrument Science Teams, one for each VLT instrument, consisting typically of three or four community astronomers and one staff member from the Science Division. These ISTs of which four are now active, are an effective means of exerting the future VLT users' influence on the programme as well as ascertaining that knowledge of that programme can diffuse into user circles. For VLTI it is intended to form Interferometric Imaging Science Groups (IISGs) which will bid to build VLTI instruments and commit themselves to help ESO commission, tune and operate the VLTI on Paranal.

Administrative Matters

One measure of the administrative load of an organization is the amount of money it spends. The ESO annual budget, with the VLT capital programme in full swing, is now about twice as high as it was five years ago. A modest increase in staff, further computerization and the cumulative experience of the several teams have maintained ESO's reputation of effective administrative procedures as the work load grew. Especially the Contracts and Procurements department is affected by VLT activities. It has risen to the task with remarkable effectiveness, often evoking appreciative remarks from our contractors even as they squirm under the rigours of our contractual conditions and their meticulous application. The reliability and consistency of our relations to industry are an important feature of ESO's reputation as a contractual partner.

ESO Public Relations

In the Office of the Director General the Information Service has during my time taken on several additional tasks. Press releases and press photos continue to be issued as developments warrant; we produce no managed news, no froth. This group, the IPS, has acquired new skills in the production of video programmes and video clips, in a remarkably short time achieving a level of professionalism equal to its more classical photographic forms of expression. The travelling exhibitions, also enhanced by ESO videos, were increased in number and scope. Part of ESO's mission is the dissemination of astronomical discoveries and insights to the public-at-large: our astronomers' explorations are journeys to be shared. That the group at the same time mass-produces and distributes posters and slides, looks after the *Messenger* and the Annual Report as well as preprints and conference proceedings is well known. Less known but important for the world-wide community is the task we took on of producing and disseminating the Palomar-ESO Atlas of the Northern Sky.

The Scientific Committees

The most direct feedback the DG gets about La Silla is from staff and fellows returning from an observing trip and via the end-of-run reports which I always read and act upon where necessary. Less direct, but comprehensive and official is the annual meeting of the Users Committee. The UC in my time has become more assertive and also more systematic in its reporting and advising. For that the members, one from each member state, have to stay in touch with their national user-colleagues, a tall order especially in the three large nations. The UC has stimulated a lot of activities, both on La Silla, e.g. the writing of a whole series of operating manuals as well as the general ESO Users Manual; and at Headquarters, e.g. measures to stabilize the MIDAS core.

The committee with the most hard labour is the OPC, the Observing Programmes Committee. In my five years the OPC adjudicated some four thousand proposals for periods 42 through 51; for the latter there were 492 normal proposals plus 8 Key Programme proposals. This stream of ideas for which telescope time is requested far exceeds the capacity of La Silla, so the work of the OPC is hard, some members say heartrending. The Visiting Astronomers Section in the DG's Office handle and prepare this semiannual flood for OPC assessment and then process the decisions by converting them into a La Silla schedule and a travel schedule for hundreds of our users. Here also the increasing workload had led to only a much smaller increase in staff time and a large increase in productivity by further automation, and sheer experience and dedication. This interplay between ESO staff and OPC members is a pleasure to monitor. The OPC has been strengthened by three members at large in addition to the national representatives, to balance the committee in special expertise and to cope with the load. Nevertheless each member spends between four and six working weeks per year for the cause. And then the national representatives have to try and answer the difficult questions of disappointed colleagues as to why their brilliant idea did not get the telescope time it so evidently deserves. Because more than half the proposals get no time at all, for the big telescopes only one in five is successful. So the frustration is large, the questions are tough. Churchill said that democracy is the least bad form of government; we have each time to convince our friends that peer review is the least bad form of distributing scarce science resources . . . The OPC spends, necessarily, a lot of time on Key Programmes, where I have from the start also involved referees external to the OPC who send their report to the OPC to complement the members' assessments. The OPC has again reached the limits of its capacity and my successor will either have to expand it again or split the task for several subdiscipline groups as is done for the HST. Whatever is done, the OPC has shown exemplary dedication and unfailing professionalism in which it has been very rewarding to participate.

The Scientific Technical Committee has in these five years seen its role much enhanced, in part by the VLT programme which has so much occupied its attention, in part by the agreement in my first meeting with the STC to not avoid controversy, to forget politics and have substantial, frank science and technology exchanges (this in marked contrast to the style when I was myself a member of the STC). The result has been a deeper involvement with much more community input as well as intellectually more rewarding meeting days. No doubt this has rather increased the feedback to the institutes where STC members are active. All in all a considerable gain in approaching the idea of ESO.

Of these three science committees all people asked to serve as members in my time have consented without fail. This is, I think, a mark of ESO's stature in our community.

The Member States Delegations

The science committees are from member States but the members come as scientists, do not represent member State governments. The members of the Finance Committee and of the Council do; we fly the flags when they meet officially, as they normally do twice per year. Their task and authority are set out in the ESO Convention and in the Financial Protocol. The Director General receives instructions and guidelines from Council, which also approves the budget and major decisions, including appointments of senior members of staff.

The FC advises Council and exercises several functions delegated to it by Council, most important of which perhaps is that of approving executive proposals to conclude contracts. The introduction to the Annual Report 1991 gives an interesting example of this activity in VLT practice.

This is not the place to elaborate on the Executive's relations with delegations or on the delegations' internal relations. It is clear that there is a great variety of interests, national and individual, of personalities and styles, which combine to form a complex and sometimes unpredictable whole. My professional training, as one Council member put it to me, has made me articulate but not very diplomatic. In the end the tremendous workload and my diplomatic weakness, which could perhaps have been corrected by a much greater time investment, time I did not find, resulted in increasing estrangement between several delegations and myself. Thus the confidence base, essential for successful continuation, eroded.

The delegations have, for these five years, persuaded their governments to provide ESO with all the means necessary for its mission. The limits of our work were in human resources, not in funding. Council understandably and effectively controls the expenditure growth by putting ceilings on the numbers of the several categories of staff that can be on the payroll at the same time. That actually determines the scope of ESO's work and the pace of its VLT programme. The member States' support has been very impressive and has relieved us of the constant money worries which plague so many other organizations, so that we could fully concentrate on the work itself. That is ground for appreciation and optimism.

A Personal Note

Ending this "farewell article" on a personal note, I must admit I had underestimated the cultural complexity of ESO at all levels. In governing bodies, in committees, in management teams and among personnel, there are so many perceptions of authority, notions of hierarchy, appreciations of frankness and openness, that the learning process is a long and subtle one. In Chile this is even more difficult. This culture diversity is extremely interesting in its dynamic patterns; it is extremely difficult to handle managerially and in policy making.

Looking back, I am convinced we have collectively achieved a great deal. I worked on the premise that all-out service to the idea of ESO, to the furthering of research opportunities of the community for which it exists, was necessary and sufficient. I have no regrets of being an idealist in this respect.

As an ESO staff member and advisor to the new Director General, I hope, at some distance, to continue to serve and observe. I look forward to resuming my scholarly work, to meeting community astronomers in their own institutes and at conferences. The Council decision may well be a blessing in disguise for my personal and our family life. After two activist decades in Leiden and five exciting but exhausting years in ESO, I anticipate a welcome change of pace. I have not had a chance for full time study, research and writing since my graduate student days in Cambridge thirty years ago!

I express my gratitude to all who have made these years so fascinating, many of whom share with me the idea(l) of ESO. May it flourish on Paranal, on La Silla, in Santiago, in Garching and throughout Europe's astronomy community.

Developments in ESO/Chile

In the course of 1992 important events took place related to ESO activities in Chile. Some of them require clarification in order to avoid the circulation of unnecessary rumours related to ESO's relations with the Government of Chile, the local staff and the Paranal site.

Relations with Chile

Concerning the general relations with Chile, the ESO Council decided in its 67th Meeting on June 4 and 5, 1992, to offer Chile membership in ESO and invited a Chilean delegation to start discussing this issue with ESO in Europe. This offer was made on the background of similar discussions which had already taken place in the 1960s and taking into account the wish of the Chilean astronomical community for closer scientific cooperation with ESO, including the desire to obtain a fixed percentage of observing time.

The offer of membership was transmitted to the Chilean Government in June this year, followed by some high-level meetings with Chilean government officials in Santiago. Apart from more formal communications confirming the receipt of this offer and its appreciation, the Chilean side has not yet replied to the invitation to begin discussions aimed at ESO membership.

The ESO Council at its 68th Meeting on December 1 and 2, 1992, discussed this issue, and a new initiative by ESO is now in preparation.

Local Staff Matters

Issues raised by the ESO local staff in Chile concentrate on the recognition within ESO of a national syndicate which the Chile local staff has established on the basis of national Chilean law and also on the request to reach a salary level comparable to that of the international staff.

Like other international organizations, ESO, because of its status, cannot accept national trade union activities within the organization.

(Continued on page 8)

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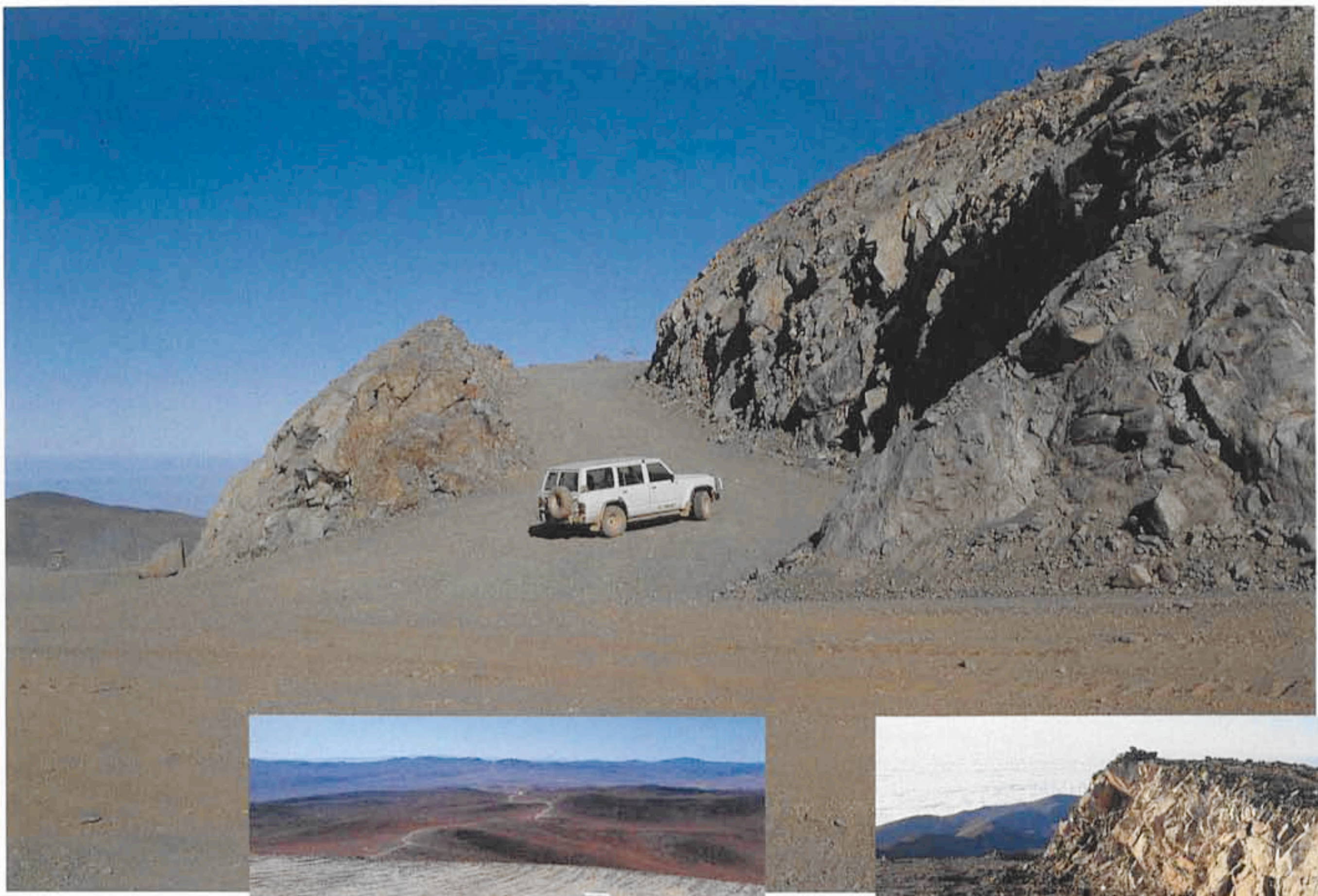
Paranal

(October 1992)

Picture 1: Paranal as seen from the NTT-peak. The truck, visible at the top, gives an idea about the dimension of the platform. – Picture 2: The new shape of the mountain clearly stands out against the deep blue sky. – Picture 3: Access road to the VLT control building. – Picture 4: Upper part of the access road leading to the platform. – Picture 5: Sunset light illuminates the wall of an excavation for a telescope basement. – Picture 6: Excavation for the basement of Telescope Unit 4 – Picture 7: Excavators at work. Photos by H. ZODET, ESO



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The principles of freedom of association for their staff are implemented in international organizations exclusively through their own legal system which, in case of ESO, recognizes the jurisdiction of the Administrative Tribunal of the International Labour Organization in the case of disputes between the organization and its staff.

At ESO this legal system consists of the Combined Staff Rules and the Local Staff Regulations which forsee the election of staff representatives for the interaction with the Executive.

At the same time ESO has no objection to local staff being members of national trade unions. Such unions can, however, not become the recognized discussion partner in matters of the local staff.

It must be emphasized that the International Labour Organization has confirmed ESO's position.

International organizations employ local and international staff. International staff at ESO, as in many other International Organizations, is recruited and remunerated on a different basis to that of local staff. At the same time, following a long-standing Council policy, the remuneration of the ESO local staff is based on the level of the best-paying employers in Chile.

The Local Staff Regulations are at present under revision and will be discussed in a specially appointed Working Group of the Finance Committee starting in January 1993. The proposed revision of the Local Staff Regulations has been discussed with a special Local Staff Advisory Committee and local staff representatives will participate in the work of this Working Group.

G. BACHMANN, ESO

Preparation of Paranal

In November the Interbeton contract for the levelling and landscaping of the Paranal site of the VLT Observatory was completed with the signature of the protocol of acceptance of the work.

The top of the mountain now presents a plateau 2632 m above sea level in which specific excavations for the foundation of the four 8-m telescopes and the control building were dug out. A total volume of about 350000 m^3 of rocks was removed during one year of hectic activity and the result is illustrated in the pictures presented in this issue of the *Messenger*. Immediately after the conclusion of the Interbeton work a geological and geotechnical investigation of the characteristics of the soil at the location of the telescopes and control building was started by Prof. Antoine of the University of Grenoble.

The main conclusions confirm the early results established in the previous explorations when one considers both the geological model for the foundation of each telescope and the estimated geotechnical characteristics of the rock masses involved.

Foundation conditions are excellent for all four telescopes. The presence of an important strip of much foliated diorite at the location of telescope No. 4 is not worrying for the stability, even if it is impressive when looking at the map. The main reasons are, firstly, the strongly reinforced concrete foundation slab acts as a bridge stepping over the shear zone and secondly, the settlements to be expected on such a zone, if they are about ten times more than those of massive rocks, remain very small with no consequences for the concrete.

The stability of the foundation slabs with respect to sliding under seismic effects is widely insured.

The control building also presents excellent conditions with respect to the small loads to be exerted on the footings, and the dip of the rock layers towards the heart of the slope which is very favourable.

Mining Activities

ESO has been informed of a plan, exploring the possibility of a large-surface salpeter mine to be opened in the south/south-east of Paranal outside the ESO property at a distance of approximately 21 km from Paranal.

Explorations have been terminated and one is waiting now for the investment decision of the owners of this mine before starting possible exploitation. The possible effects of dust and light pollution on Paranal are presently being studied. In this connection it is noted that 85 % of the wind is in the north-south direction and only a small portion of the dust, and under unfavourable conditions, may drift to the north at altitudes which are not yet clearly determined.

The mine has already informed ESO that it is willing to discuss protective measures in favour of the observatory, should it be decided to start exploitation of the mine.

M. TARENGHI, ESO

ESO to Help Central and Eastern European Astronomers

The Council of the European Southern Observatory[1], meeting at the ESO Headquarters in Garching on December 1–2, 1992, has decided to initiate a Programme by this organization, aimed at supporting some of the scientifically most active and internationally highly esteemed astronomical institutes and research groups in Central and Eastern Europe (C&EE).

Earlier this year, the ESO Council established a special Working Group to provide advice about ESO's future relations with C&EE astronomy under the recent changes in Europe. At the same time, there have been numerous reports about the steadily and dramatically worsening situation of astronomy in these countries, even the possible demise of some of the C&EE institutes and observatories. In many places it now seems that astronomy is in a particularly difficult situation when compared to some of the more applied sciences.

Following consultations with many individual C&EE and West European astronomers and authorities, the Council Working Group concluded that immediate action should be taken by ESO. It recommended that a diversified programme of support to some of the scientifically most active institutes and research groups in the C&EE be initiated.

The Council agreed that ESO, as the major European astronomy organization, and with its many links to individual researchers, scientific institutes and observatories as well as to policy makers, is in an optimal position to assess objectively the very diverse needs and to provide support to C&EE astronomy in a non-bureaucratic and cost-effective way.

The Council resolved that a total of up to 500,000 DM from the ESO budget will be made available for this purpose during each of the next three years. Still, it is obvious that ESO within its limited means can only muster a small fraction

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[1] The Council of ESO consists of two representatives from each of the eight member States. It is the highest authority of the organization and normally meets twice a year.

of the total support needed. However, by assuming the role of a clearing house, ESO will be able to channel support from other sources.

The ESO Programme will be strictly based on scientific excellence. Applications from C&EE astronomers will be reviewed by the appropriate ESO Committees, acting in close contact with astronomers and institutes in the ESO member States.

A primary goal is to enable C&EE astronomers to continue to do good research while remaining at their home institutes, and also to induce young and promising scientists to stay in this field. For this reason, the ESO Programme comprises a variety of measures, in particular support for collaborative scientific programmes, including fellowships, participation in conferences, shorter-term visits by Western astronomers to C&EE institutes, as well as transfer of equipment and publications.

The gradual implementation and the detailed action plan will be worked out under the guidance of the new ESO Director General, Professor Riccardo Giacconi (see ESO Press Release 05/92), who takes up his duties at ESO on January 1, 1993. It is expected that this new ESO Programme will take effect immediately thereafter.

From ESO Press Release 10/92
(3 December 1992)

More detailed information about this ESO Programme will become available in early 1993 and will be forwarded to astronomical institutes/observatories and individual astronomers in C&EE Countries, as far as they are known to ESO. In order to ensure the widest possible distribution, all interested parties are herewith invited to express their wish to receive this information by sending a short message with their exact postal address to the *ESO C&EE Programme* at the ESO Headquarters (address, etc. on the last page of this *Messenger* issue).

ESA Astronaut Claude Nicollier Visits ESO

On December 7, 1992, Swiss Astronomer and Astronaut Claude Nicollier visited the ESO Headquarters in Garching. At a special colloquium in the main auditorium, he told the ESO staff about his many exciting experiences, on the ground and in particular during the recent flight of the space shuttle Atlantis which carried the EURECA platform to its orbit on July 30, 1992.

Dr. Nicollier began his career at the Geneva Observatory and is a long-time friend of our organization. He stayed several times as visiting astronomer at La Silla, before he moved closer to the stars. He arranged that an ESO flag was carried aloft on the Atlantis flight; together with a flight certificate this flag was handed over to the ESO Director General, Professor Harry van der Laan, immediately after the talk (see the photo). The Director General gratefully received this valuable gift which will be displayed on a prominent place in the ESO Headquarters building.

In his own words, Dr. Nicollier enjoyed again being at ESO and among fellow astronomers. We were particularly happy to learn that he had just been assigned to the shuttle mission, which will perform the crucial repair of the Hubble Space Telescope in late 1993. It is difficult to imagine a more important service which could be rendered by an astronaut to his "ground-bound" astronomers!

We wish Dr. Nicollier and his astronaut colleagues every success with this daunting endeavour. And we hope that he will again find time to visit ESO.

The Editor

ISAAC – Infrared Spectrometer And Array Camera for the VLT

A. MOORWOOD, ESO

Overview

ISAAC is one of the two instruments in the VLT Instrumentation Plan being designed and integrated in-house at ESO. Identified formerly as the Medium Resolution Infrared Spectrometer/Imager it will provide mainly for both direct imaging and low and medium resolution spectroscopy at wavelengths from 1 to 5 μm and is scheduled to be installed at one of the Nasmyth foci of Unit Telescope 1 in early 1997. We are now in the detailed design and prototyping phase following approval of the instrument Technical Specification and Design and Implementation Plan by the ESO Scientific and Technical Committee in November 1991 and the Preliminary Design Review involving external experts in April 1992.

Scientific Capabilities

Infrared observational capabilities have been revolutionized by the availability of two-dimensional array detectors which have made both imaging and the efficient use of dispersive spectrometers at these wavelengths possible for the first time. Within the space of a few years we have evolved from single pixel photometers and spectrometers to cameras and spectrometers equipped with first 64×64 and now 256×256 element arrays. In terms of performance/pixel there is already little more to gain for ground-based instruments as the best of these arrays already exhibit quantum efficiencies in excess of 80 %, dark currents below 1e/s and read noises ~20e. Further increases in size up to formats of 512×512 in the near future and perhaps eventually 1024×1024 or even larger, however, are now being anticipated.

ISAAC is conceived as one of a new generation of infrared instruments which harnesses these new detector capabilities to the increased light gathering power of the VLT and provides the user with the flexibility to combine imaging and spectroscopic observations in a way not possible previously in the infrared. The baseline instrument currently being designed operates from 1 to 5 μm, has a 2×2 arcmin field and provides the following basic observing modes:

- Direct imaging through broad- and narrow-band filters with selectable scales in the range ~0.1–0.5 arcsec/pixel.
- Long slit spectroscopy at resolving powers in the range ~300–10,000 with a maximum slit length of 2 arcmin and slit widths of ~1–0.2 arcsec.
- Polarimetry by combining polarizing analyzers and filters in the pupil plane.

At present, the baselined detectors are the 256×256 arrays already available. The instrument is being designed to accommodate the larger arrays anticipated, however, in which case some of these characteristics may change somewhat e.g. due to the likely reduction in pixel sizes. The design also leaves open a number of additional options for future upgrades e.g. image sharpening by tip-tilt control of the telescope secondary mirror; imaging spectroscopy using Fabry Perot etalons and echelle spectroscopy using grism cross dispersers in the pupil plane. Given the complexity of the basic instrument, however, these additional capabilities still have to be carefully traded off against the possible increased technical risk and operational complexity.

ISAAC covers a wide spectral range over which the sky and telescope background increases by a factor $\sim 10^5$ from the shortest to the longest wavelength with a corresponding effect on the achievable performance. Nevertheless, we expect to be able to image objects down to magnitude ~25 in the J (1.25 μm) and ~15 in the M (4.8 μm) bands and to obtain spectra at resolving powers around 5000 of objects ranging from magnitudes ~20 to 12 over the same range.

With regard to the scientific potential of ISAAC it should be noted that the availability of infrared array detectors

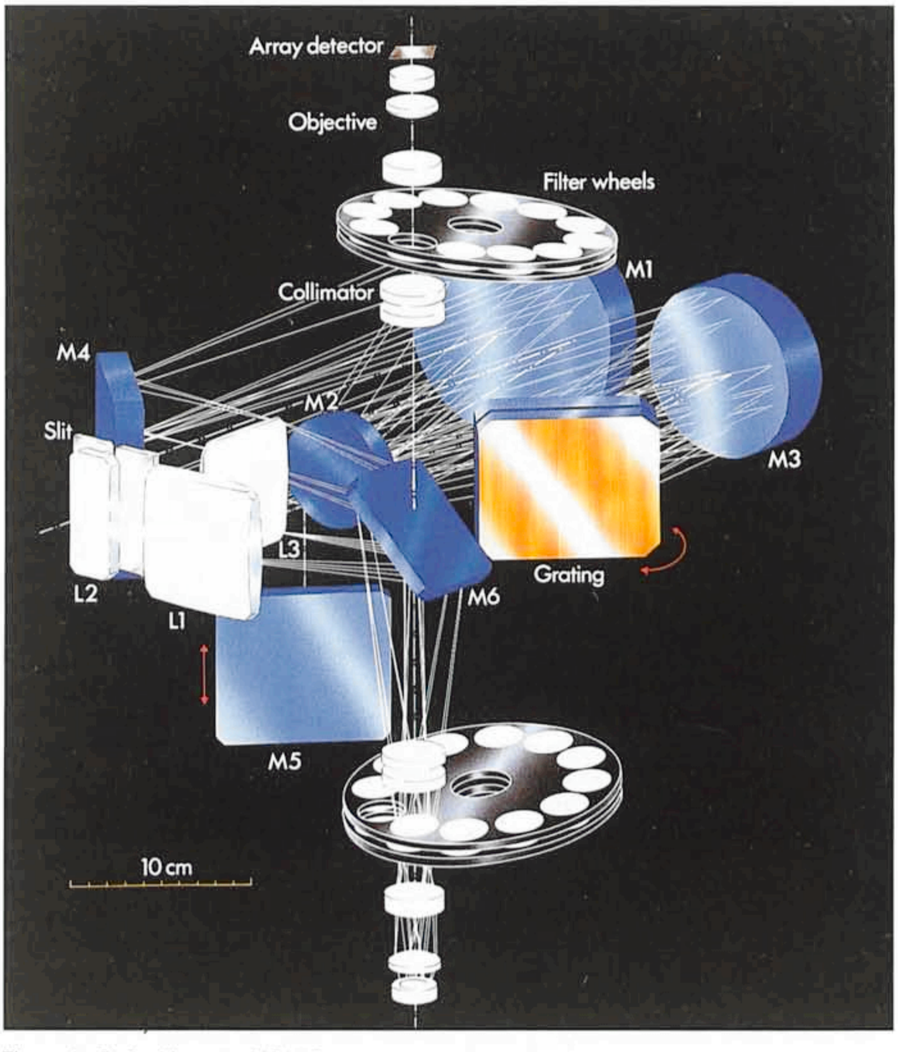


Figure 1: *Optical layout of ISAAC.*

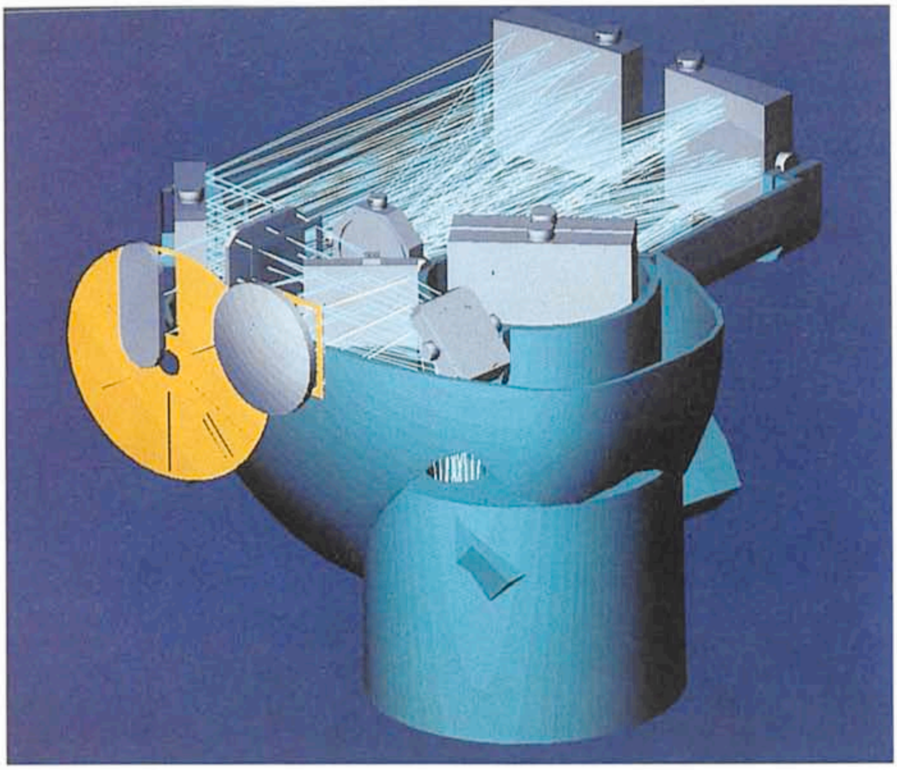


Figure 2: *ISAAC cryogenic optical assembly.*

has not only closed the technical gap but has also removed some of the mystique which previously separated visible and infrared astronomy. Observing with infrared arrays of CCDs in the visible is now very similar, and extrapolating from the interest currently shown for ground-based infrared imaging and spectroscopy it is expected that ISAAC will be in demand for a wide range of astronomical programmes involving observations of essentially all classes of object known. On the one hand infrared observations will remain the prime tool for the study of many objects which are either too cool or too heavily embedded in dust to be usefully studied at shorter wavelengths. These include the solar-system objects, cool stars, recently formed stars in molecular clouds, the centre of our own and many other galaxies, etc. traditionally associated with infrared astronomy. For such studies ISAAC offers a powerful multimode capability for imaging, photometry, polarimetry and spectroscopy. With regard to the latter it should be noted that its spectral range covers a number of important spectral features including the well-known 3.28-μm PAH feature, the ro-vibrational molecular hydrogen emission lines, CO and other molecular absorption bands, many hydrogen and helium recombination lines and various ionic forbidden lines spanning a wide range of ionization potentials from the important shock excited [Fe II] lines to the [Si VI and VII] coronal lines. Spectroscopy in this range also has much to offer therefore beyond its unique roles in the study of molecular gas and visually obscured sources. Similarly, many imaging studies only possible previously in the visible may be usefully extended to the near infrared either for astrophysical reasons or simply because the effects of extinction are much less. Examples include cluster photometry and morphological studies of galaxies where e.g. apart from much lower extinction the infrared images are dominated by late-type stars which constitute most of the mass. Where the VLT will obviously make its greatest impact is clearly for studies of those faint objects and spectral features which are below the detection limits achievable with smaller telescopes. It will be of interest to make deeper searches e.g. for low-mass stars in clusters and for the elusive brown dwarfs and to extend studies confined so far to our galaxy to the Magellanic Clouds. It will also substantially increase our ability to detect and study a class of infrared object not so far mentioned – high-redshift galaxies. The stellar light of nearby 'normal' galaxies peaks around 1 μm and galaxies at redshifts $z > 1$ are expected to be more easily detectable in the infrared than the visible while important "visible" spectral features will only be observable in the infrared. Amongst the most exciting prospects offered by ISAAC therefore are the new possibilities it offers for surveys and studies of galaxies and clusters over a wide range of cosmologically interesting redshifts.

Optomechanical Design

The optical arrangement of ISAAC is shown in Figure 1. This concept aims at minimizing the compromises inherent in a multimode instrument by providing two cameras which can be used either to view the telescope focal plane directly for imaging or the intermediate spectrum produced by the grating spectrometer. It essentially comprises two separate instruments therefore which are housed together and share the same detector arrays. The two cameras are identical mechanically but are optimized separately for the 1–2.5 μm and 2.5–5 μm spectral regions optically and are each equipped with appropriate filters and detector arrays with formats of ≥256×256 pixels. The entrance window for imaging (L1) also acts as a field lens producing an image of the telescope secondary mirror on the cold pupil stops while the spectroscopic slit is located ~4 arcmin off the telescope optical axis behind a plane entrance window (L2). Each camera comprises a collimator unit (also used for internal focusing), two filter wheels, a pupil stop and a lens wheel carrying the different objectives required to provide magnifications in the range ~0.1–0.5 arcsec/pixel. In the imaging mode these cameras view the telescope focal plane via the plane selector mirrors M5 and M6. In the spectroscopic mode the light entering via the slit is collimated by the compact three mirror collimator (M1–3) to produce an 80 mm diameter beam at the grating unit which carries two back-to-back mounted plane gratings used in Littrow mode. After diffraction at the grating the beam returns via the same collimator unit to form an intermediate spectrum in a plane conjugate to the telescope focal plane which is then re-imaged by one or other of the two cameras. Although the nominal resolving power corresponds to a 1-arcsec slit using the fastest camera objective, the slower objectives can also be used allowing a reduction of the slit width and hence increases of up to a factor of ~5 in resolving power while retaining at least two pixel matching.

External to, but mounted on the instrument within the adapter flange (not shown in the picture) are a visible slit viewer and the calibration unit consisting of an integrating sphere equipped with spectral line lamps and a continuum halogen lamp which can be used to illuminate the spectrometer slit via a retractable diverter mirror for wavelength calibration and flat fielding.

A summary of the main instrument characteristics is given in Table 1.

Table 1. *ISAAC Main Characteristics*

Wavelength range	1–5 μm
Field	2×2 arcmin.
Image scales	~0.125, 0.25, 0.5″/pixel
Max. array format	~25×25 mm
Pupil diameter (camera)	25 mm
Collimated beam (camera)	25 mm
Collimated beam (spec.)	80 mm
Nominal Slit width (2 pixels)	1 arcsec
Slit length (max.)	2 arcmin
Resolving power (1″slit)	300–5000
Filters and analyzers	24/camera

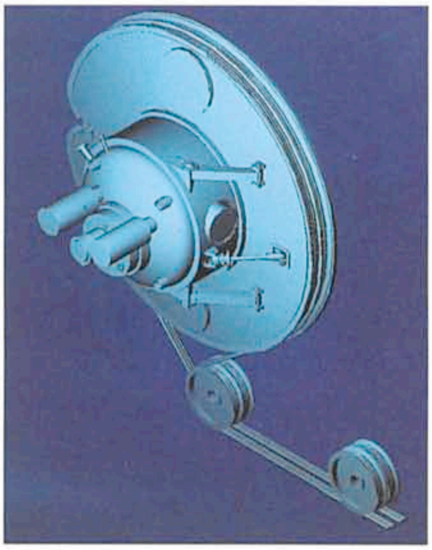


Figure 3: *ISAAC adapter flange and vacuum vessel showing the closed-cycle coolers and permanently mounted turbomolecular pump and the cable wind systems*

Apart from the slit viewer, calibration unit and the two entrance windows all optical elements together with their mechanical support structure are cooled to a temperature of ~80K using a continuous flow liquid nitrogen system and maintained at their normal operating temperature of 60–80K using the first stages of two closed-cycle coolers. The detectors are cooled to temperatures of between 20 and 60K using the second stages of the closed cycle coolers. Diamond-turned aluminium alloy mirrors and gratings ruled or replicated on aluminium are used in the cryogenic optical assembly and all moving functions are driven by cryogenic stepper motors. A simplified view of how the optics are integrated into the mechanical support structure is shown in Figure 2. The entire optical/detector assembly is surrounded by a light tight radiation shield which is also at 60–80K and is attached to mechanical support struts via which it is mechanically connected to but thermally isolated from the enclosing vacuum vessel. This latter, shown in Figure 3, is basically a cylindrical tank whose axis is on the horizontal optical axis and comprises a rigid central section which supports the cooled optical assembly and is attached to a stiff, dome-shaped, adapter flange bolted to the Nasmyth rotator. On the telescope side it is closed with a plane flange which carries the imaging and spectroscopic input windows and on the other by a light dome providing the space for, but not supporting part of the optical assembly and to which are attached the two closed-cycle coolers and the turbomolecular pump used for evacuating the vessel. The hinge system visible on the right allows the instrument to be swivelled away from the adapter flange to provide access to the front flange and to the units attached to it and within the adapter flange. The control and data acquisition electronic modules are located in a temperature controlled cabinet(s) attached to the instrument. Cables and the hoses for cooling fluid and the closed cycle coolers are wound on guides attached to the adapter flange and pass via a length compensation system to minimize the torque on the rotator during operation.

Array Detectors

Two channels are provided in ISAAC primarily to permit the installation of optimized detectors for the short (1–2.5 μm) and long (2.5–5 μm) wavelength ranges whose requirements with regard to dark current, read noise and well capacity are different. At present the baseline detectors for the short and long wavelength channels respectively are the currently available 256×256 pixel Rockwell NICMOS3 Hg:Cd:Te and SBRC InSb arrays. Given the on-going developments in this field, however, the instrument is being designed to accommodate larger-format arrays if and when they become available in the future.

In order to gain experience with large-format arrays of relevance to ISAAC as well as providing new observing capabilities at the present ESO Observatory on La Silla, a new camera, IRAC2, and a flexible VME-based acquisition system have recently been installed and successfully tested at the 2.2-m telescope (see *The Messenger*, **69,** 61). This camera has been equipped initially with a NICMOS3 array and provides for imaging through broad- and narrow-band filters, including a K band scanning Fabry Perot etalon yielding R ~1000, with five selectable magnifications in the range 0.15–1.1″/pixel and a maximum circular field of 3″ diameter.

Electronics/Software

Both the function control and detector electronics will use intelligent VME-based LCUs (Local Control Units) housed in the temperature-controlled cabinet(s) attached to the instrument adapter flange. Each detector will have its own dedicated "front end" electronics (generating clock patterns and voltages, ADC conversion strobes, etc.) connected via a fibreoptic transputer link to a common pre-processor (performing number crunching e.g. for multiple sampling techniques and limited on line data reduction such as image co-adding, bad pixel removal, etc.). The control LCUs and the detector pre-processor will communicate via the VLT data/control LAN with the host Instrument Workstation through which the observer will interact with the instrument.

User Interface

ISAAC will be remotely controllable from the Instrument Work Station (IWS) which could, in principle, be physically located at any place which is connected by a suitable computer link. At this IWS the observer will interact with the instrument via User Interface which is common to all the VLT instruments and through which the required observing/calibration modes and parameters will be input. The IWS will also run instrument specific software providing for a simulation mode, the generation of automatic observing sequences, maintenance checks and status display. MIDAS will also be available on-line for image display and quick-look analysis.

Development Status

Detailed design work started after the Preliminary Design Review in April 1992 and is scheduled to be completed with the Critical Design Review in summer 1993. ISAAC is a technically complex instrument. Exploiting large array detectors on a large telescope requires a large instrument which has also to be operated at cryogenic temperatures but still meets the stringent flexure requirements imposed by its rotation on the Nasmyth adapter. Because of this rotation not only control and signal cables but also the high pressure helium lines for the closed-cycle coolers and fluid lines for the electronic cooling circuit have to be routed via a cable wind system which allows for the rotation and minimizes torque on the adapter. The high background modes of ISAAC also place difficult demands on the speed of the data-acquisition system. In order to meet these various requirements, the preliminary design of ISAAC incorporates a variety of technologies for which little practical experience is available and for which sound design and analysis alone is not considered sufficient. These include the use of diamond-turned metal mirrors, stepper motors, position sensors and large-diameter bearings at cryogenic temperatures and under vacuum. In order to minimize risk therefore, we are currently prototyping the most critical functions for test in a specially designed cryogenic test facility before finalizing the design and starting the manufacture which will be largely contracted to industry.

Project and Science Teams

The ISAAC Project Team within ESO is:
A. Moorwood, Instrument Responsible/Scientist
P. Ballester, MIDAS reduction software
P. Biereichel, Control and data acquisition software
J. Brynnel, Control electronics
B. Delabre, Optical design
G. Finger, Detectors and system performance
G. Huster, Mechanical design
J.-L. Lizon, Cryogenics, integration, tests.
M. Meyer, Detector electronics
A. van Dijsseldonk, Instrument Manager and procurements

Members of the ISAAC external Instrumental Science Team which reports to the VLT Programme Scientist are G. Miley (Leiden, Chairman), R. Chini (Bonn), E. Oliva (Florence) and J.-L. Puget (Paris).

UVES, the UV-Visual Echelle Spectrograph for the VLT

H. DEKKER and S. D'ODORICO, ESO

Overview

UVES is one of the two instruments in the VLT Instrumentation Plan being designed and built by ESO. It is a crossdispersed echelle spectrograph with a nominal resolution of 40,000 with a 1 arcsec slit. This double-beam instrument uses 22×85 cm mosaic echelle gratings, grating crossdispersers and thinned CCD detectors with 2048^2 pixels each, one for each arm. It will be mounted at the Nasmyth platform on a horizontal optical table inside a protective enclosure (Fig. 1). We are now in the preliminary design phase following the approval of the Design and Implementation Plan by the Scientific Technical Committee and Council in their May/June 1992 round of meetings. The Preliminary Design Review is planned for 20/21 April 1993. UVES will be built in two copies; the instrument schedule foresees the installation of UVES1 at the Nasmyth focus of Unit Telescope 2 in the second half of 1997, of UVES2 at UT3 about 12 months later.

Observing Capabilities

Echelle spectrographs are instruments of highest priority in all of the large telescope projects because high resolution spectroscopy is one of the observing modes which benefits most from the larger collecting area. The stellar flux is dispersed over a large number of detector elements and for objects of faint magnitudes the shot noise of the signal is comparable to the detector read-out and dark current noise. In this regime, the S/N ratio increases with the second power of the telescope diameter, and the gain in using the VLT becomes very significant. In the observations of brighter objects where the photon statistics is dominating other sources of noise, the large aperture of the telescope is still needed to achieve in reasonable exposure times very high S/N ratios and to follow spectral variations on short time scales. It is also

Figure 1: *3-D view of UVES with most of the enclosure panels removed for clarity.*

essential to include in the design provisions for accurate wavelength and intensity calibration and to minimize the amount of scattered light in the spectrograph.

The report of the VLT Group on High Resolution Spectroscopy (VLT Report No. 50, 1986) includes a review of the scientific programmes which require observations with spectral resolutions in the range 10^4–10^6. They concerned basic studies of the physical conditions and chemical composition of matter in stellar or gaseous bodies. The data to be obtained are relevant to any modelling of the past history and the future evolution both of our galactic environment and of the universe as a whole. The goals of this observing mode remain essentially unchanged today. In a first approximation two types of programmes and corresponding requirements on the instrument can be identified. First, those which call for observations of the faintest objects over a wide spectral range with low to medium S/N ratios and at resolution in the range 10^4 -10^5. Examples of this category are the studies of abundances in galactic and extragalactic stars and of the primordial gas in the universe through QSO absorption lines. They require an instrument of high efficiency to take full advantage of the larger telescope size with a wide spectral coverage to observe lines spread over a large spectral interval. At the magnitudes that one is likely to observe, the possibility of accurate sky subtraction also becomes essential. A second category of programmes calls for spectral resolution higher than 10^5, in more restricted wavelength regions, and generally, but not always, with very high S/N ratios. Examples are the studies of the physical conditions in the interstellar clouds through the observations of the equivalent widths and the profiles of lines of atoms like Na and Ca and molecules as CN and CH, of the abundance of Lithium isotopes in the interstellar medium and studies of stellar oscillations from the observed variations in the profiles of lines originating in the stellar atmospheres.

In UVES which offers a nominal resolution of 4×10^4 for a 1 arcsec slit in a crossdispersed format, the first category is well covered by the instrument equipped with the standard camera/detector combinations. However, the concept permits to also attain the higher resolutions required by the second category by using a long camera combined with image slicers. In this case the separation of the orders is not required for sky subtraction, but to accommodate the long exit slit of the image slicer. In order to have stable, well characterized instruments, the most attractive option seems to be to replace the blue camera on UVES2 by a high-resolution camera. The tradeoff is still being analysed and will be decided upon in 1993. Factors affecting the decision are on the one hand a detailed investigation of the optimum spectrum extraction methods and the final S/N ratio that can be achieved in this mode (which will be

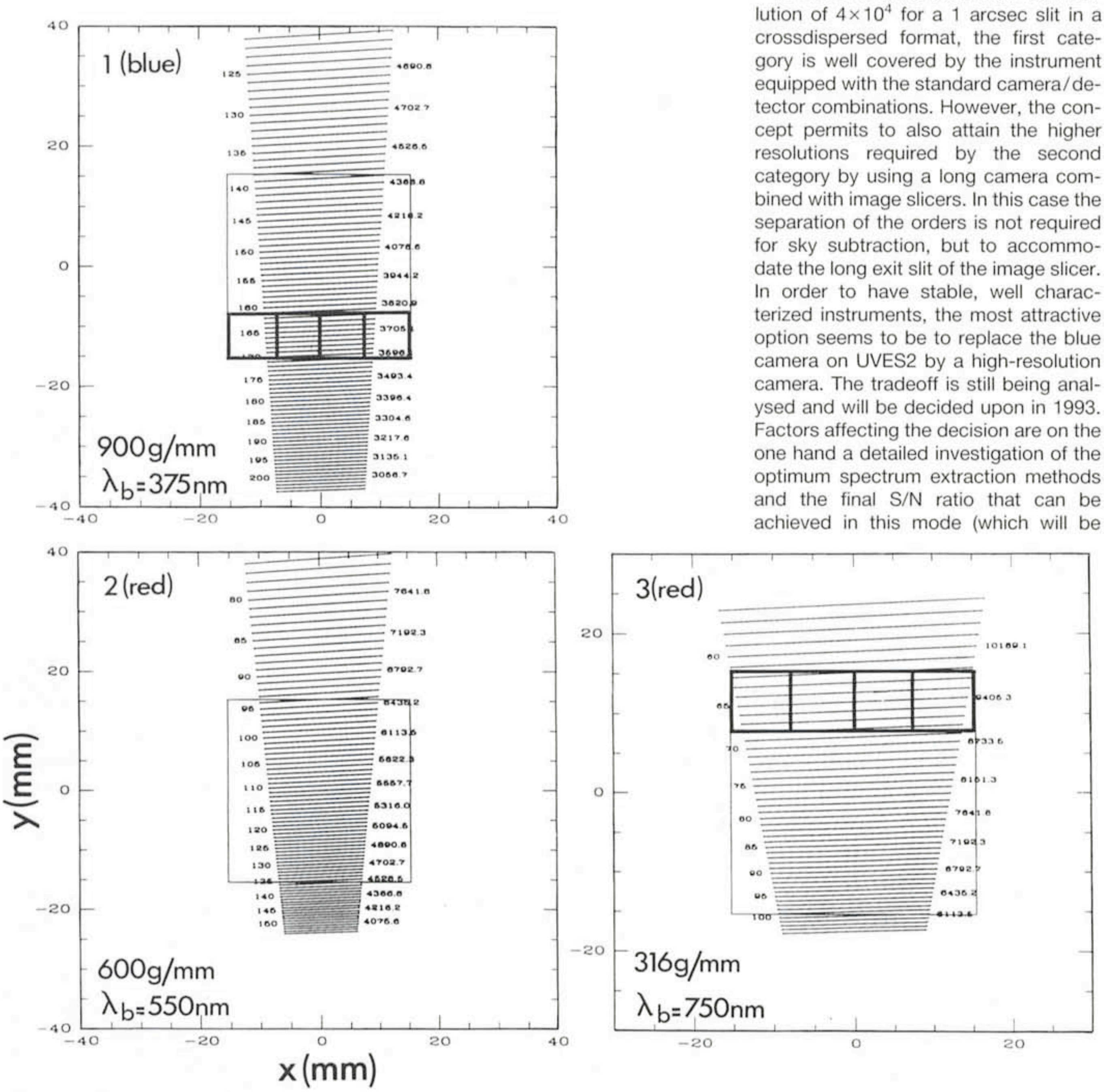


Figure 2: *Spectral formats with the crossdisperser gratings. These are mounted on turntables so the central wavelength can be set by the user. The thin-line square the field of the CCD detector with the F/2 (blue) and F/1.25 (red) cameras respectively. The heavy-line rectangle shows the field of the 4×1-CCD mosaic with the F/5 camera.*

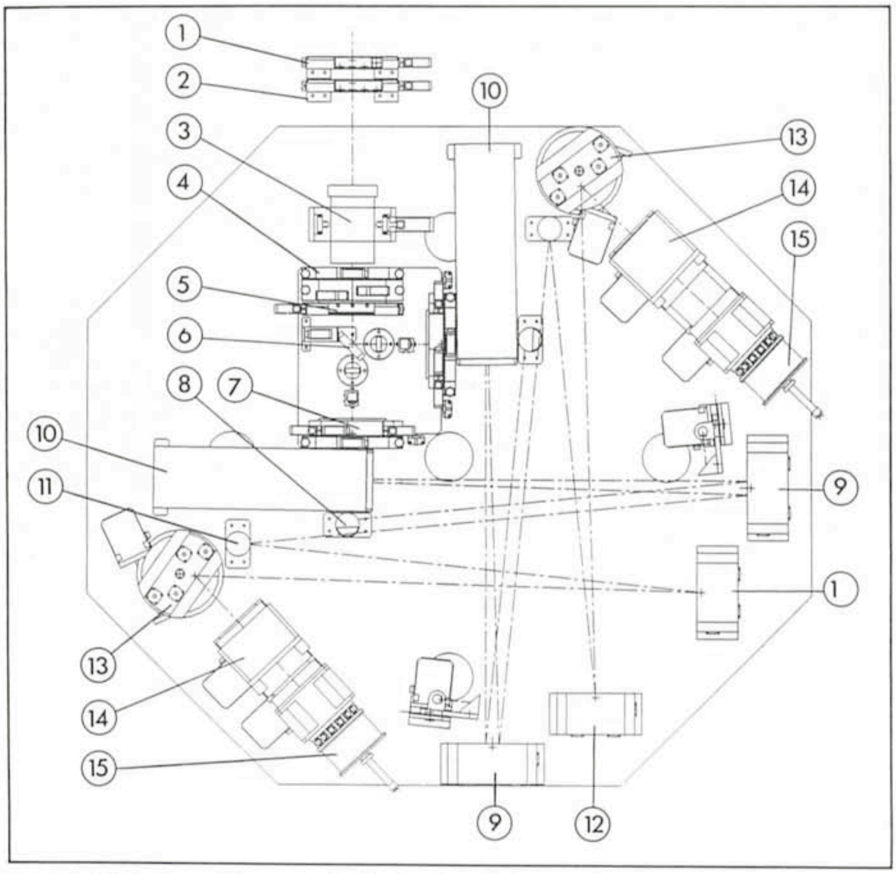


Figure 3: *Plane view of the optical table showing the layout of UVES. Legend: 1 = calibration system. 2 = image slicer unit. 3 = image derotator. 4 = filter wheel. 5 = pupil stop. 6 = mode selector (blue/red/dichroic). 7 = slit. 8 = folding mirror. 9 = main collimator. 10 = R4 echelle. 11 = intermediate spectrum mirror and stray light stop. 12 = pupil transfer collimator. 13 = crossdisperser grating unit. 14 = camera. 15 = CCD detector head and continuous flow cryostat.*

affected by the spectral format peculiar to image slicing, wavelength calibration, detector noise considerations, frequency of radiation events, etc.), the expected demand of the blue and long cameras and the properties and expected performance of the high resolution spectrograph for the incoherent combined focus. The expected performance that UVES would have with the different camera options is summarized in Table 1 while the spectral formats are shown in Figure 2.

Optomechanical Design

The instrument functions are placed on a horizontal optical table with a height of 1.7 metres above the Nasmyth platform. Figure 3 shows a plane view of the layout on the optical table. Advantages of a table are good accessibility and ease of handling of functions and flexibility in view of possible future changes, for instance in the area of CCDs and cameras. Only the calibration unit, image slicer and image derotator are mounted on the rotator. We plan to use an optical table with super-Invar top and backing sheets. Since Invar has an expansion coefficient much lower than that of steel, this will reduce the sensitivity to vertical temperature gradients that might cause the table to bend, which is important since the main dispersion direction is perpendicular to the table surface. The table is supported by a welded frame on three spherical supports. The frame itself rests on three pads on the Nasmyth platform. The control and CCD electronics are located in a temperature controlled cabinet outside the enclosure.

The enclosure consists of a welded steel frame and isolating panels mounted on the frame. Thermal stability is essential to achieve good radial velocity accuracy and a stable focus of the lens cameras. A preliminary calculation shows that without any active temperature control, the temperature of the instrument will change by not more than 0.05 deg C/h during typical observing conditions, which we consider sufficient. The instrument is equipped with temperature sensors at various locations on the table and the enclosure.

The calibration unit, containing a 45-degree mirror, flatfield and ThAr lamps, is mounted before the F/15 Nasmyth focal plane. The mirror slide also mounts an Iodine cell which – when inserted into the telescope beam – produces a dense forest of absorption features in the object spectrum in the region 4800–6000 Angstrom and provides a very stable reference for radial velocity measurements. Bowen-Walraven image slicers mounted on a motorized slide can be placed in the F/15 focal plane.

UVES uses an imaging derotator that is shared by both arms. The user selects the arm(s) used with a 4-position slide that can move from the free (red) position to a blue mirror or one of two dichroics with two different cross-over points. The collimated beam is focused by red or blue doublets on the corresponding slits that are each equipped with slit viewing cameras. We are investigating the implementation of Atmo-

Table 1: *Main parameters of UVES*

	Red	Blue	High Resolution
Wavelength range	0.42–1.1 μm	0.3–0.52 μm	0.3–1.1 μm
Resolution-slit product	4 x 10^4	4 x 10^4	4 x 10^4
Camera	dioptric F/1.25	dioptric F/2	reflective F/5
CCD	2048^2, 15 μm (thinned)	2048^2, 15 μm (thinned)	2048^2 x 8192, 15 μm (thinned mosaic)
Typical wavelength	2500 Angstrom	900 Angstrom	600 Angstrom
range/frame	in 35 orders	in 40 orders	in 8 orders
Pixel matching	.31 arcsec/pixel	.19 arcsec/pixel	.06 arcsec/pixel
Max. resolution	~5 x 10^4 (slit .6″)	~7 x 10^4 (slit .4″)	~1.5 x 10^5 (slicer slit .2″)
Slit height	15″ typ.	10″ typ.	10–15″ (slicer 1.7 x 1.7″)
Detection efficiency (incl. telescope and slit)	10 % at 600 nm	9 % at 400 nm	10 % at 600 nm
Magnitude limit	19–20 in V (S/N = 10, 3 h)		14–15 in V (S/N = 100, 3 h)

spheric Dispersion Compensation prisms and a Polarization analyser in the preslit optical train.

The collimator is a new design developed at ESO that is very well suited for crossdispersed echelle spectroscopy and which in the meantime has also been adopted by the Munich Observatory and the Nordic Optical Telescope Group for their fiber-fed echelle spectrographs. The collimator mirrors are off-axis parabolas. From the slit which is mounted at its focus, the first parabola delivers a collimated beam on the echelle which operates in Quasi Littrow Mode with only a small off-plane angle. The dispersed beams are again collected by the main collimator and focused at an intermediate focal plane, after which the pupil transfer collimator recollimates the beams, at the same time delivering a second "white" pupil where the crossdisperser and camera are placed. This type of collimator is free of aberrations while the control over the second pupil offered by it eliminates vignetting at the crossdisperser and camera. The near-Littrow illumination improves echelle efficiency and reduces problems associated with using the echelle off-Littrow. A stray light diaphragm placed at the location of the intermediate spectrum reduces interorder stray light.

The echelle is unusually steep (for astronomy) and has 31.6 g/mm and a blaze angle of 76 degrees with dimensions ~ 220×850×125 m. Since the maximum ruled length that can be obtained is 408 mm (determined by available grating ruling engines), a mosaic is required. The usual technique that has been employed at ESO and elsewhere is to mount two single 408 mm gratings on a common substrate. For this instrument we intend to use another mosaicking technology which involves replication by the grating manufacturer of two gratings on common substrate with inherent advantages of simplicity and robustness. Figure 4 shows a photograph of a prototype grating that was recently delivered to ESO.

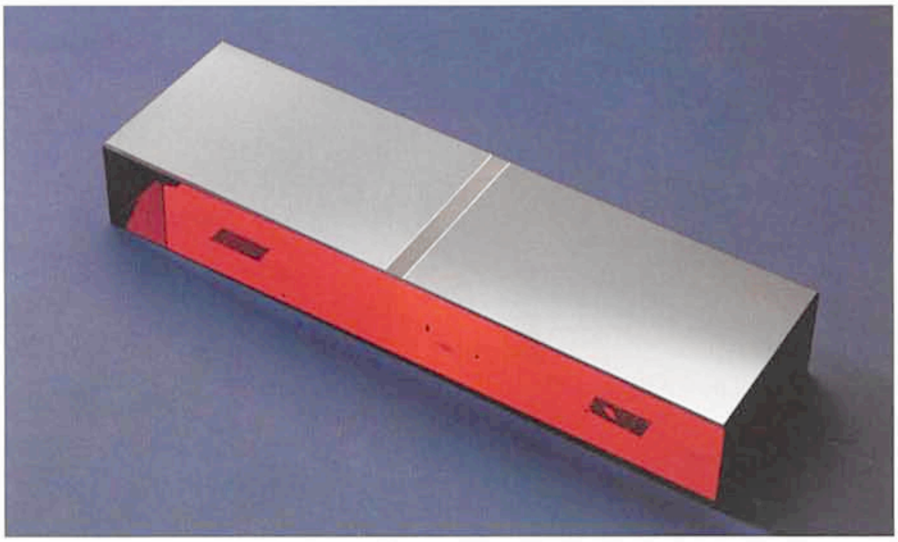


Figure 4: *Photograph of a recently delivered prototype echelle grating with dimensions 450×130×70 mm. The 14-mm gap between the two segments is due to the manufacturing procedure followed and would lead to a 2.2% light loss if also present on the full-size grating. The measured resolution of this grating is $7\cdot10^5$, close to the theoretical resolution of a single segment.*

We have extensively investigated prism/grism crossdisperser combinations but prompted by the need for large-order separation have finally settled for standard first-order reflection gratings. These are mounted back to back on a grating turntable.

The regular short cameras are fast dioptric designs offering a wide field, good imaging quality, high optical efficiency and an external focus, important to interface new detectors. Their field size and image quality is compatible with 2048^2 CCDs with 15 μm pixels. The long camera employs 4 mirrors of which 3 are off-axis aspheres and accommodates a mosaic of 4 of these chips in a row. Compared with the red F/1.25 camera, the long camera has a 4 × larger focal length so the angular fields of long camera and red camera in the dispersion direction are identical. In the crossdispersion direction the field and hence the number of orders and wavelength range covered is reduced by a factor 4. Data of the cameras are given in table 2.

Table 2: *Basic camera data*

	Red short camera	Blue short camera	Long camera
Type	dioptric	dioptric	off-axis aspheres
F/no	F/1.25	F/2	F/5
Focal length (mm)	250	400	1000
Field (mm)	43.4 mm diam.	43.4 mm diam.	30 x 120 mm
Wavelength range (nm)	420–1100 nm	300–520 nm	300–1100 nm
Back focal distance (mm)	4	4	~30
Scale (μm/arcsec)	48	78	240
Efficiency	~90%	~90%	~85%
Image quality (E_{80})	~10 μm	~10 μm	~15 μm

Detectors

The baseline detector foreseen is a 2048×2048, 15 micron square pixel detector in a thinned, backside illuminated version. The specified performance calls for a typical ron of 4 electrons, full well capacity of more than 10^5 electrons, and a QE of >30% at 350 nm and >60% at 600 nm. The device should be buttable on at least two sides to be able to build up a row of 4 which would cover the 30×120 mm field of the long camera. Such a CCD is not an off-the-shelf product. ESO has started two development programmes to obtain the required CCD within 1993. One contract with Thomson CSF in France calls for the development of a backside-illuminated version of the Thomson 7897M device. A second agreement with the Steward Observatory of the University of Arizona foresees the thinning of devices of the same format as produced by LORAL. Another thinned CCD which should be available on the market in 1993 is the 2048×2048, 24 micron square pixel CCD from Tektronix. This device would require slower cameras than the Ford or Thomson chips with a curved field matching the bow of the TEK chips. Butting of the back-up Tektronix detectors is presently not possible and we might have to reconsider the high resolution camera if the baseline CCD cannot be obtained. We will actively follow the developments in the detector area with the aim to make a final selection of the detectors for UVES towards the end of 1993. The single chips will be

Table 3: *Composition of technical project teams at ESO and Trieste Observatory*

ESO	
H. Dekker	Instrument responsible, gratings procurement and instrument testing
H. Kotzlowski	Mechanical engineering and technical coordination
P. Ballester	MIDAS reduction software
S. Deiries	Detector assembly/test
B. Delabre	Optics design and procurement
S. D'Odorico	Commissioning at the telescope
G. Hess	CAD design
O. Iwert	CCD detectors
J.L. Lizon	Component testing and optomechanical integration/test
A. Longinotti	Overall software and liaison with Trieste
W. Nees	Instrument control electronics
R. Reiss	CCD control electronics
E. Zuffanelli	Secretary
Trieste	
P. Santin	Coordination at Trieste and liaison with ESO
A. Balestra	Observation Software
M.G. Franchini	Observer Support Software
C. Vuerli	Maintenance Software

mounted in the standard ESO dewar that is being developed for a number of VLT instruments while the CCD mosaic requires the development of a dedicated dewar. The dewars will be cooled by a continuous flow of liquid nitrogen that is pumped from a nearby large vessel through flexible LN2 lines. The autonomy time of the system is expected to be on the order of weeks.

Electronics and Software

While the preceding description is very specific to UVES, the electronics and software architecture will be common to many VLT instruments so the following description reflects the overall control philosophy of the VLT, not just that of UVES. Only a brief description will be given here.

The function control and detector electronics will use intelligent VME-based Local Control Units (LCUs) housed in temperature controlled cabinets outside the enclosure. The control and detector LCUs communicate via the VLT Ethernet LAN with the Instrument Workstation. Its physical location is typically the main VLT control room but it could also be placed next to the instrument during the testing phase.

The main software modules at LCU level are *Instrument Control Software* responsible for communication with the instrument workstation and controlling all instrument functions and *Detector Control Software* to control all detector related LCUs, respectively.

Modules resident in the Instrument Workstation are *Observation Software* which is responsible for controlling observations, from the instrument setup to the storage of the data on tape, *Observer Support Software* which assists the observer to check important parameters relevant to the observation like resolution and expected S/N and *Maintenance Software* to assist the maintenance staff in documenting instrument configuration changes, aligning and doing detailed performance checks. *MIDAS* will be available as well for online data analysis. There will be special MIDAS procedures for image display, calibration and quick-look data analysis.

While in stand-alone mode, these modules will provide for simple tasks like the execution of single observations. Embedded in the whole VLT software, the UVES software will be able to take advantage of many common facilities like the *Sequencer*, which allows to define a sequence of observations corresponding to a complete night off-line, or the *Scheduler*, which allows to switch automatically from one observing programme to another if certain conditions (e.g. seeing) change during the night.

The *VLT User Interface* provides to the user, who may be a service technician, an on-site or remote observer or a service observer, a transparent communication interface with all of these modules at various selectable levels of access authorization, interactivity and automation.

ESO has recently signed an agreement with the Observatory of Trieste under which the latter will contribute 3 man-years in 1993 and 1994 to develop the Observation, Maintenance and Observer Support Software for UVES in collaboration with ESO. The agreement may later be extended to the phase of integration, testing and commissioning of the instrument if this will be in the interest of both parties.

Project and Science Teams

The composition of the technical project teams at ESO and of the software group at Trieste is given in Table 3.

S. D'Odorico is the instrument scientist at ESO. The project relies also on a team of internal scientists composed of D. Baade, Ph. Crane, G. Mathys, L. Pasquini and J. Wampler for advice on specific scientific/technical issues.

As for the other VLT instruments, UVES has a science team composed by external scientists who are kept informed of the status of the project and whose advice is sought every time a decision has to be taken which has an impact on the scientific capabilities of the instrument. They report to the VLT project scientist J. Beckers. Members of the team are B. Gustafsson (Uppsala), H. Hensberge (Brussels), P. Molaro (Trieste) and P. Nissen (Aarhus).

The Choice of the Telescope Enclosures for the VLT

L. ZAGO, ESO

1. Introduction

The final choice of the type of telescope enclosure for the VLT unit telescopes was probably one of the most critical decisions taken in the course of the VLT project up to now.

Back in 1984, at the start of the project, the work on the definition of the VLT enclosures started with the objective to study and design an "open" type of enclosure, in which the telescope would be largely exposed to the undisturbed windflow during observations. This option of envisaging an open-air

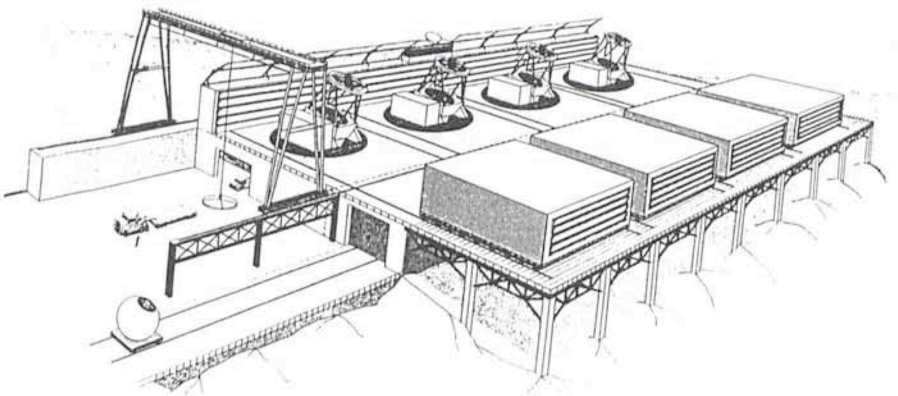


Figure 1: *The first artist's view of the VLT (1984).*

operation of the VLT unit telescopes had been essentially suggested by the favourable experience with the MMT and the NTT, which had broken with the conventional dome concept [1]. Indeed all the evidence available from both traditional and innovative telescope enclosures points to the fact that letting some wind flow on the telescope will reduce or even eliminate dome seeing. Besides the reduction of dome seeing, another main design driver was the objective to drastically lower the cost of the telescope enclosures, so that the entire VLT project could be realized within a budget frame compatible with what was felt were the financial possibilities of the organization.

Thus the very first artist's view of the VLT (Fig. 1) saw the four unit telescopes completely exposed during observations and protected during the day by movable roll-on/off shelters. A large wind screen, nevertheless, had the function of decreasing the wind force on the telescope. For many reasons this first enclosure "concept" was not very practical; however it illustrates well the objectives that were set for the enclosure with respect to the windflow: the enclosure should allow on the telescope as much windflow as required for eliminating local seeing, while limiting the amplitude of wind buffeting to levels acceptable for the optimum tracking performance of the telescope.

The problem of achieving a good tracking performance of the VLT also in presence of strong wind will be solved by the design of a servo-controlled tilting secondary mirror which will provide a dynamic correction of the high frequency telescope oscillations that cannot be reduced by the main tracking control loop acting on the main telescope drives. One could indeed demonstrate that with this system the telescope will be able to achieve a tracking accuracy better than 0.05 arcsec even in the worst wind loading case [2].

The effects of wind buffeting on the primary mirror, however, were not fully quantified until quite late in the VLT development. Although a possible criticality of this aspect had been recognized at an earlier stage, a fact that led to the modified "open" enclosure design in which nevertheless the lower part of the telescope was relatively well protected in a cylindrical recess (Fig. 2), it was thought that the active mirror support system could be made capable of dynamic figuring corrections up to a frequency of the order of 1 Hz [2]. Unfortunately this ambitious objective turned out to be impossible, due in particular to hardware limitations of some components of the mirror supports. Therefore the VLT mirror will have by design only its own rigidity for reacting against wind buffeting and, because of the high mirror aspect ratio, the upper limit specified for wavefront aberrations sets an allowable limit for the pressure fluctuations on the mirror surface of 1 N/m^2 rms [3].

This issue ultimately drove the choice of the VLT enclosure towards a type in which the primary mirror could be effectively protected from any wind pressure fluctuation larger than the above-mentioned value.

2. The Main Options Investigated for the VLT Enclosures

The development of the enclosures had to be done in parallel with that of the telescope and the mirror support system. Therefore, while the problems related with telescope tracking and buffeting on the primary were analysed in parallel, different enclosure types were the object of detailed feasibility studies. The main options that were considered during this preliminary phase are briefly described here.

2.1 The Retractable Enclosure

This design represented for a long time the baseline for the VLT enclosure. In its final form (Fig. 2) the retractable enclosure consists of a fixed base and a rotating part. The fixed base is made of a metal space frame ring-shaped structure and supports the rotating part on a number of roller bearings. The upper rotating part is made of an approximately cylindrical panel clad space frame, which constitutes a wind shielded re-

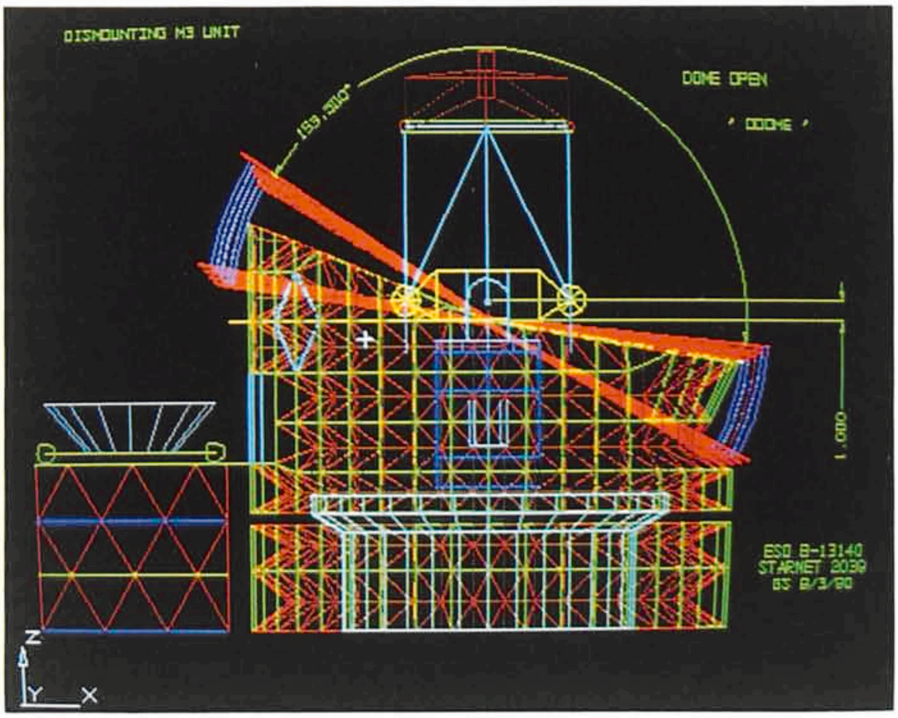
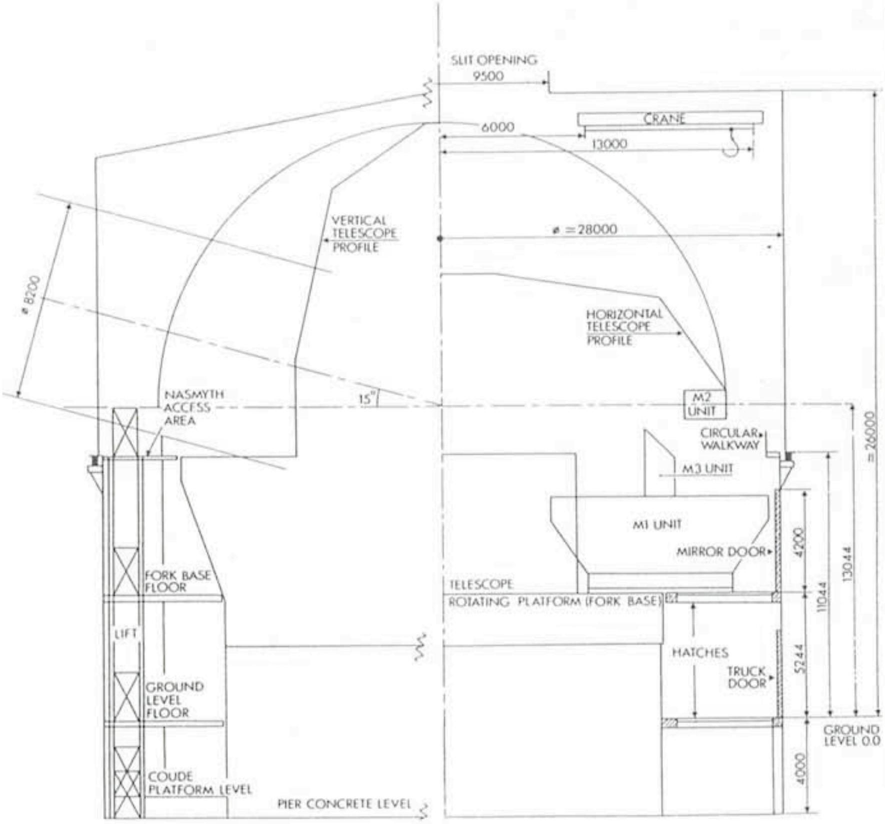


Figure 2: *The retractable enclosure for the VLT (solid shell version).*

The VLT Enclosure from the User's Standpoint



Schematic cross-section of the VLT enclosure.

Here is a brief description of the selected VLT enclosure, emphasizing the aspects which are likely to be of most interest to future users. A schematic cross-section of the enclosure is shown in the figure. Access for personnel to the enclosure will be either via the underground utility tunnels that connect all the buildings of the telescope area or a normal door at the ground-floor level. Staircases and a lift will connect all floors of the enclosure. A large external door at ground level will allow entry of trucks with large instruments and goods in the so-called ground access room, which covers a quadrant of about 90° at ground level. The rest of the ground floor is made of exposed radial walls which support the metal structure surrounding the telescope room.

At the underground floor a 360° ring of rooms will surround the telescope pier and give access to the pier interior where the coudé instruments will be located. Miscellaneous service equipment will be installed in these rooms, such as the oil pumps for the telescope bearings, but ample space will remain for storage of users' items, which may be quite useful particularly during the installation of instruments. Large equipment items will be lowered down to the underground floor by the dome crane, through a hatch in the floor of the ground access room.

The crane, installed radially just under the roof of the dome, will be the main handling tool for all maintenance operations inside the enclosure and, by rotating the dome, will be able to serve the whole telescope volume except the central region. This crane will be used to mount the Nasmyth adapters and instruments, to install and remove the secondary mirror unit (with the telescope in horizontal position), as well as to lift the tertiary mirror unit before the exit of the primary mirror cell on its way to the aluminization plant. Another hatch will allow the crane to pick up loads from the ground access room into the telescope room.

Inside the telescope room there will be two floor levels. The fork base floor, about 5.2 m above the ground level, will constitute a continuous surface with the rotating azimuth platform of the telescope. Cassegrain instruments will be mounted and accessed on this floor. The upper floor level, 11 m from the ground level, will be continuous with the Nasmyth platforms of the telescope over a 90° quadrant: this area will be the main access way to the Nasmyth instrument for personnel and small equipment. Only a narrow circular walkway will run all along the inner wall of the enclosure, permitting maintenance access to the dome rotation drives and wheels.

During the day and in general when the enclosure is closed, the thermal control system will keep all internal surfaces inside the telescope room at a set temperature close to the predicted value for the coming night: this will prevent, after opening the dome, the rise of convective flows that may affect the seeing quality. This thermal conditioning will be achieved by air cooling and mixing: in order to achieve the desired heat transfer rates with all surfaces, the mixing rate may be set at up to 10 volumes/hour. Therefore, daytime users of the enclosure should expect to find a somewhat (literally) cool working environment, while the noise of fans and air treatment units should not exceed the level usual for rooms equipped with individual air conditioning equipment.

In addition to the thermal control system, the enclosure will include a variety of mechanisms for dome rotation, opening, louvers, etc. All these systems will be managed by a network of computerized controllers linked both to the Telescope Control System network and to the Building Management System (which monitors and administers all service supplies on the site). Therefore the observer will not only be able to operate from his/her control station all the enclosure mechanisms linked to telescope operation (such as dome rotation and slit opening) but will also be able to inquire at any time about the status of all active components of the enclosure.

L. ZAGO, ESO

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cess in which the lower part of the telescope is contained, topped by a retractable hemispherical dome. Two possibilities for the dome were extensively studied: an inflatable dome made of a pressurized double fabric supported by rigid hoops, or a dome consisting of overlapping shell sections connected along a common axis to the rotating cylindrical part.

Both enclosure versions with the dome in solid shell sections and the inflatable dome were the object of a detailed feasibility study and the inflatable dome design was also thoroughly tested by building a 15-m prototype dome at La Silla (Fig. 3). This dome, erected in 1988, is now planned to be used by Bochum University as the dome for their new Hexapode telescope.

2.2 The NTT-type Enclosure

An alternative enclosure type which was studied in some detail was a scaled-up, simplified version of the NTT building installed at La Silla (Fig. 4). While the other enclosure types limit the observing elevation to 10–15° above the horizon, the NTT-type enclosure would allow observation down to the horizon. It features large, upside down L-shaped doors to cover the observing slit as well as louvers around the periphery of the building, which allow some direct ventilation of the telescope at any azimuth. Like for the NTT, a semi-permeable wind screen can be raised across the slit.

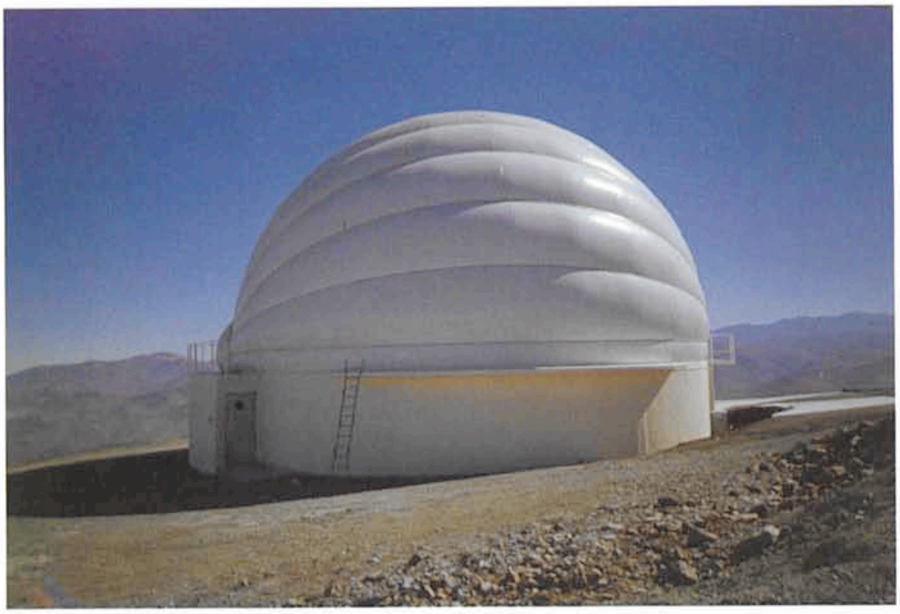


Figure 3: *The 15-m inflatable dome prototype at La Silla.*

The enclosure co-rotates permanently with the telescope but, contrary to the NTT building, the Nasmyth rooms are not separated from the telescope volume, which also results in a considerably simpler and more reliable thermal control system. The disadvantage of an NTT-type enclosure is that it implies a relatively high rotating mass, which causes design constraints to structural and mechanical parts and ultimately makes this solution more expensive than the other ones. This concept was therefore in the end not retained for the VLT.

2.3 The Cylindrical Enclosure

The drawbacks of the NTT-type enclosure with respect to the VLT requirements and the wish for a reasonably conventional alternative to the retractable dome enclosure led to a proposal for a cylindrical enclosure with a two-sloped roof (Fig. 4). Here the design consists of a basement in concrete with a height of about 5 metres from the ground level, which supports a steel structure that encloses and provides access to the telescope. The fixed part of the metal structure rises up to the level of the telescope Nasmyth platform, which simplifies considerably all accesses as compared to the two enclosure types previously described. Near the level of the primary mirror there are some large ventilation openings which, together with the mirror door, may allow some natural ventilation also on the primary mirror.

The rotating part does not include any accessible floors and has essentially the same function as a conventional observatory dome, from which it differs by its optimized structural layout and the presence of large, upside-down L-shaped slit doors quite similar to the NTT-type. The cylindrical shape of the "dome" also allows the easy installation of an internal crane. The two-slit doors are supported on two protuberances of the dome, which also integrate a set of pneumatically activated bars that constitutes a wind screen with different levels of wind permeability across the slit. In the dome itself, a large number of louvers may provide natural ventilation in the entire telescope volume.

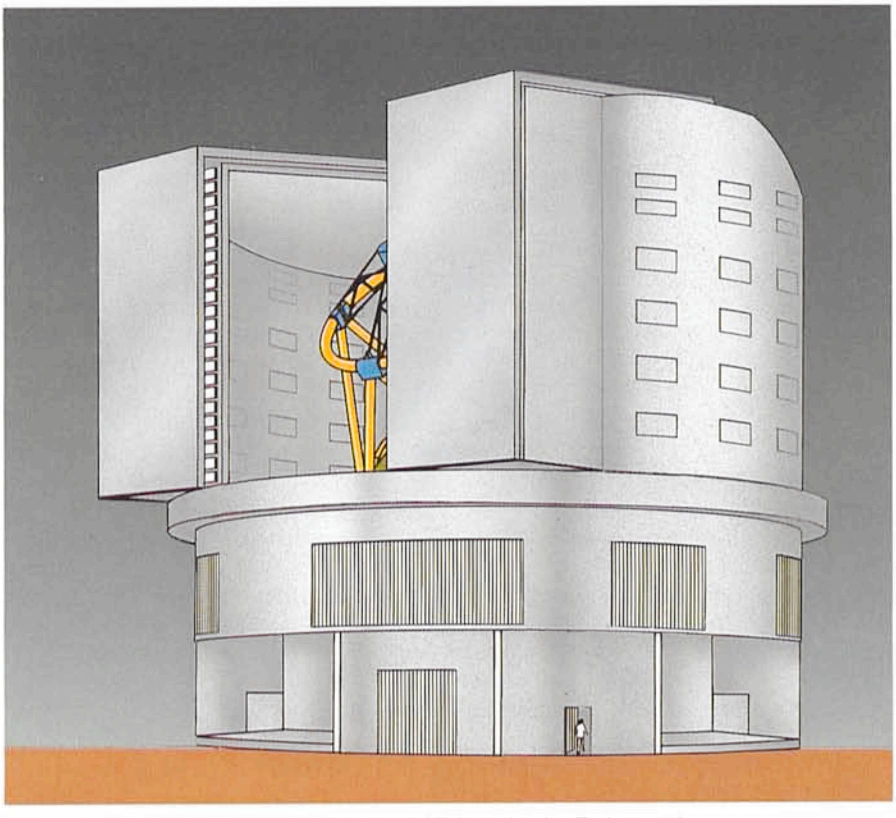


Figure 4: *The cylindrical enclosure for the VLT (drawing by E. Janssen).*

3. The Final Selection

Both the retractable and the cylindrical enclosures do not present any technical problems and meet all requirements with respect to the protection of the telescope in the closed enclosure. Also the estimated manufacturing and erection costs are too close to be a deciding factor for the choice.

Indeed the main difference between the two types is in the different degree of wind shielding given to the telescope during observation. The cylindrical enclosure can give the telescope a natural ventilation which ranges from full protection to reasonable, but anyway limited air flow across the telescope volume. On the contrary, the retractable enclosure leaves the upper part of the telescope essentially in open air and can limit the wind load on the lower part only up to a certain limit.

Thus the final choice was driven by an analysis of the impact of the local seeing and wind loading effects inside the enclosure on the overall telescope performance. The seeing aspect would clearly favour the retractable enclosure: with some simple design precautions, essentially aimed at reducing radiation cooling during the night, this enclosure would provide a practically seeing free environment to the telescope. Concerning the wind loading aspect, this situation is also favourable with respect to the tracking performance: the active secondary mirror unit would in any case achieve a very good tracking performance even in the worst wind conditions. However, the question is much more critical for the 8-m primary mirror.

Wind tunnel tests were performed to evaluate the air flow patterns in the retractable enclosure: these measurements showed that the primary mirror is located in a recirculation region in which the local flow speed will reach up to 3 m/s when the wind blows outside with a speed of 18 m/s (the maximum operational mean wind speed for the VLT). Air flows of 3 m/s would be considered in other circumstances a light and welcome breeze but here it has to be considered that this will already cause pressure fluctuations on the primary up to about 4.5 N/m^2 rms depending on mirror orientation. This level of pressure fluctuations does not cause any problems for conventional 4-m class mirrors, but the aspect ratio of the 8-m VLT primary is so large (as a comparison term, the VLT primary is intrinsically 37 times less rigid than the 3.5-m NTT mirror) that it can maintain an optimal figure only under pressure fluctuations of up to about 1 N/m^2 rms. The conclusions of these analyses were rather obvious: because of the high sensitivity of the VLT primary mirrors to wind buffeting, the retractable enclosure may not provide adequate protection in all cases, even if it would probably provide the best seeing conditions.

A "closed" enclosure, that would provide under all wind conditions a good protection of the primary mirror had to be preferred. Nevertheless, in order to achieve an optimal optical performance in all circumstances, it was deemed desirable to keep the possibility of some degree of natural ventilation of the telescope volume. Therefore, the selected cylindrical enclosure includes a number of flexible ventilation possibilities with a semi-permeable wind screen across the slit, louvers in the upper part and some large opening in the lower fixed part. Wind tunnel tests have shown that the critical speed range with respect to pressure fluctuations on the mirror starts already between 1.5 and 2.5 m/s. Therefore, it is clear that the margin for getting some useful natural ventilation is small, although it will exist in some circumstances.

In general, however, the VLT will be able to achieve a consistently low mirror seeing only by means of a tight temperature control of the primary. Computations based on reduced scale experiments and the application of relevant similarity laws indicate that, for instance, if the mirror can be brought at the start of the night within a ΔT of 0.2° with respect to ambient air and then made to follow the relatively small (on the average) temperature changes during the night that are experienced at Paranal, then the mirror seeing of the VLT will be limited to about 0.1–0.2 arcsec in the worst cases and be reduced to something like 0.03 arcsec, if and when natural ventilation of the primary has been optimally trimmed.

References

[1] Zago L., Environmental effects and enclosure design for large telescopes, Proc. ESO Conf. on Very Large Telescopes and their Instrumentation, pp. 855–866, Garching, March 1988.

[2] Quattri M., Zago L. and Plötz F, Design evolution and performance evaluation of the VLT telescope structure, Proc. ESO Conf. on Very Large Telescopes and their Instrumentation, pp. 127–146, Garching, March 1988.

[3] Noethe L., Cui X. and Stanghellini S., ESO VLT – Primary Mirror Support System, Proc. ESO Conf. on Very Large Telescopes and their Instrumentation, Garching, April 1992.

Something is Going On in the ESO-Libraries

U. MICHOLD, ESO-Library, Garching

The UNICORN
Collection Management System

Did you happen to visit the ESO-Libraries lately? And did you notice the librarians sitting in front of their computer terminals, staring at the screen, sometimes smiling as if in a trance or – on the contrary – sighing deeply? Looking at this unusual scene, you might have wondered what has changed, and then come to the conclusion: There is something going on in the ESO-Libraries.

You are right. Actually, we are in the middle of an important project: the computerization of the ESO-Libraries.

The Start: Just Pretending

A move from the traditional way of operating a library to an integrated computerized library system had been intended for some time already. Early this year, we eventually found an automated system that meets nearly all our requirements regarding features and functionality, ease of use, and compatibility with the ESO computer environment. The name of the software is Unicorn, and we expect it to turn a myth into a legend, as the vendor claims in his advertisement.

In July 1992 the software was installed on ESO's Sun-machine ns0. From the start, Miguel Albrecht kindly took care of all technical aspects including security and back-ups. At the beginning of August all librarians from Garching and La Silla attended a 5-day training course in Garching. After this intensive learning, we knew how to use all modules of the Unicorn system, and fortunately we were able to test everything on a trial database first. At this time we also started to look for a contractor who could carry out the retrospective conversion of the existing card catalogue.

Now it's for Real

The "luxury" of being "happy-go-lucky" and doing whatever we liked on the system came to an end in September, when the whole database and every modification we had made so far was deleted. Since then it has been "sink or swim", any mistake we make from now on will have an impact on our own database (although everything regarding setting up policies, entering and deleting data, etc. can be changed later if it turns out not to be the right decision).

Our new colleague, Uwe Glas, took up work in mid-September. In early November we are approaching 2,000 online bibliographic records already! Believe it or not, it's so much fun to see your "own" database grow – and it makes your incredibly proud! Now you might think that it's not the purpose of a library system to make the librarians feel proud – and again you're right. So why all this activity?

Why it is Worthwhile

An automated library system means a lot of advantages. Let me describe some of the improvements to explain why it is worthwhile committing a large amount of manpower to getting the new system running.

Online Access

One of the main advantages is the online accessibility of the whole library catalogue. Via the so-called OPAC (Online Public Access Catalogue) users will have access to the catalogue from their own terminals. No knowledge of any retrieval language will be required because of a self-explanatory, menu-driven user interface. All available options will be displayed on the screen, the user only has to choose one and enter his search terms. In addition to this well-guided query mode, experienced users may search in a more sophisticated way, e.g. using Boolean operators (AND, OR, NOT), proximity searching (words within a specified distance) and other options.

The bibliographic record of every "hit" which has been retrieved can be displayed and will give details about the item including information about the status (on shelf/on loan). This facility reduces the time library users have to spend at present on their search: Often they go to the trouble of finding out the exact shelf number of the required item, only to find out that it is already on loan.

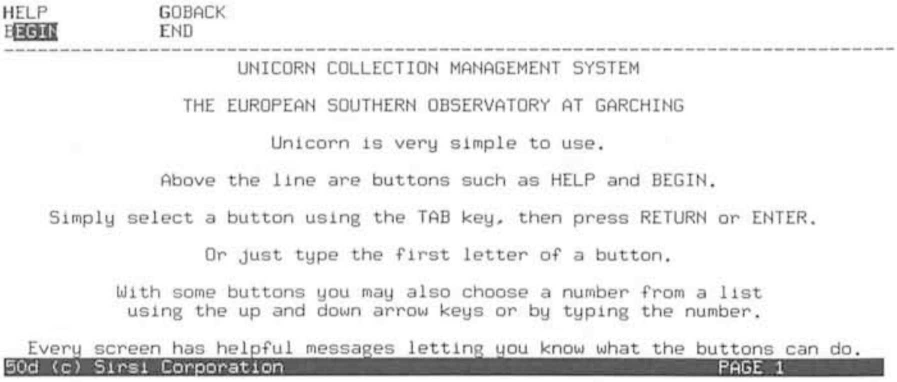
Retrieving Items

You will probably know that at present you should better come prepared with exact bibliographic data if you want to be sure of finding an item that is actually available in the library. If so, you can use the card catalogue and look up e.g. the author's name.

If you are looking for literature related to a given subject, it will be harder to find appropriate items. No keyword indexing is provided at the moment, and the only access to the contents of a book is via the ESO classification system. This classification system has been developed in-house over the years, and it is neither very detailed nor up-to-date regarding several of the sub-divisions. Therefore, users often browse directly through the books on shelf, hoping to find interesting items just by chance. Unfortunately, the chances are not very high, since books on similar subjects might be spread over several classification groups.

This situation will improve to a large extent. The computerized system will offer access to every word or phrase in the bibliographic record, regardless of whether it appears in the subtitle, in the General-notes-field or somewhere else.

A major argument against computerized library catalogues is the concern that users have about being forced to follow the rules of the system when searching and not being able to switch between several enquiries intuitively. To ensure a really convenient way of searching, we have chosen a software that makes use of an application of the hypertext technique. Hypertext simulates the way users usually search by allowing to "browse and navigate" through the database intuitively. Based on hits the user has already retrieved, he can continue the search under a different aspect without having to leave several sub-menus to start again.



```
HELP                GOBACK
BEGIN               END
--------------------------------------------------------------------------------
                     UNICORN COLLECTION MANAGEMENT SYSTEM

                  THE EUROPEAN SOUTHERN OBSERVATORY AT GARCHING

                          Unicorn is very simple to use.

                Above the line are buttons such as HELP and BEGIN.

      Simply select a button using the TAB key, then press RETURN or ENTER.

                     Or just type the first letter of a button.

             With some buttons you may also choose a number from a list
              using the up and down arrow keys or by typing the number.

   Every screen has helpful messages letting you know what the buttons can do.
50d (c) Sirsi Corporation                                            PAGE 1
```

Figure 1: *UNICORN Collection Management System welcoming screen.*

```
HELP                GOBACK              STARTOVER
CHOOSE:1
--------------------------------------------------------------------------------
                           PUBLIC ACCESS CHOICES:

                            1) LIBRARY CATALOG

                            2) BULLETIN BOARD

                            3) USER STATUS




50d (c) Sirsi Corporation                                            PAGE 1
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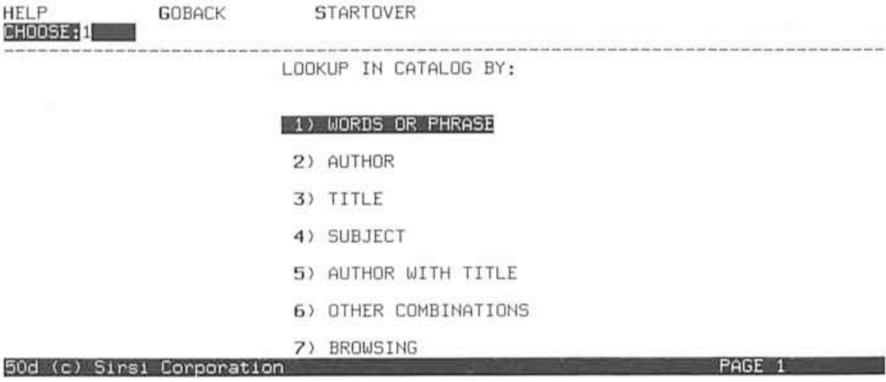
Figure 2: *Starting a sample in the Library Catalogue.*



```
HELP                GOBACK              STARTOVER
CHOOSE:1
--------------------------------------------------------------------------------
                           LOOKUP IN CATALOG BY:

                            1) WORDS OR PHRASE

                            2) AUTHOR

                            3) TITLE

                            4) SUBJECT

                            5) AUTHOR WITH TITLE

                            6) OTHER COMBINATIONS

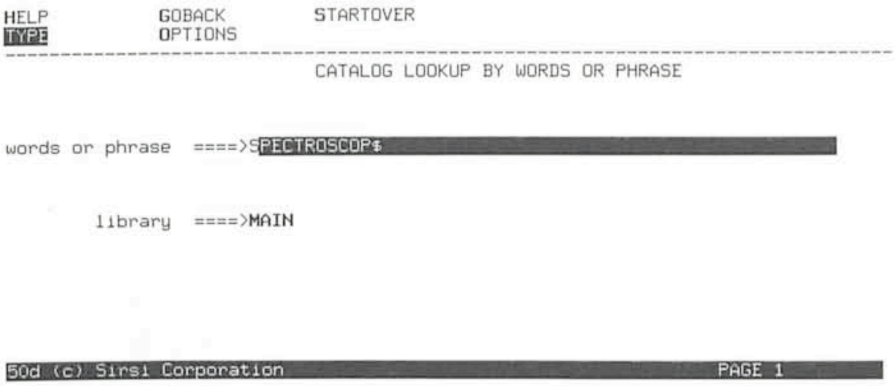
                            7) BROWSING
50d (c) Sirsi Corporation                                            PAGE 1
```

Figure 3: *Lookup in Catalogue by words or phrase.*

Items can be retrieved not only once they have arrived in the library, but as soon as any data have been entered into the database, e.g. for acquisition purposes. Thus, users can check whether a book is already on order.

Information About New Acquisitions

At any time, users will be able to obtain information about the latest acquisitions in the libraries. The "Bulletin Board" will offer lists of new items available in Garching, La Silla, La Serena, and later also Paranal. Of course, these



```
HELP            GOBACK          STARTOVER
TYPE            OPTIONS
------------------------------------------------------------------------------
                                CATALOG LOOKUP BY WORDS OR PHRASE


words or phrase  ====>SPECTROSCOP$


        library  ====>MAIN




50d (c) Sirsi Corporation                                        PAGE 1
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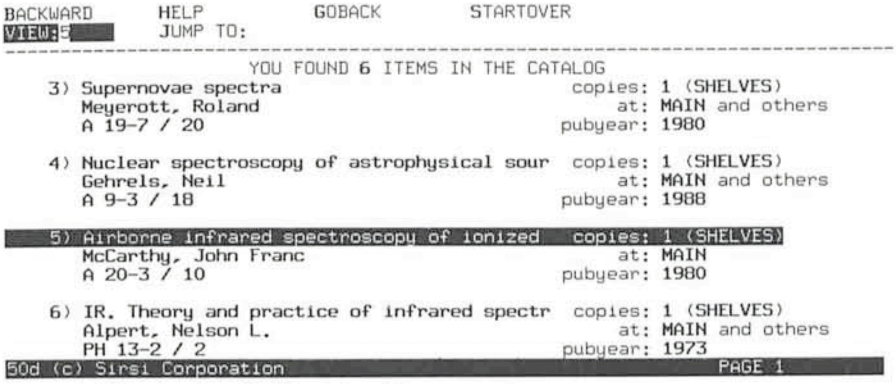
Figure 4: *Searching the database for the word SPECTROSCOP$ (includes spectroscopy, spectroscopical, etc.*



```
BACKWARD     HELP          GOBACK        STARTOVER
VIEW:5       JUMP TO:
------------------------------------------------------------------------------
                     YOU FOUND 6 ITEMS IN THE CATALOG
    3) Supernovae spectra                             copies: 1 (SHELVES)
       Meyerott, Roland                                   at: MAIN and others
       A 19-7 / 20                                   pubyear: 1980

    4) Nuclear spectroscopy of astrophysical sour     copies: 1 (SHELVES)
       Gehrels, Neil                                      at: MAIN and others
       A 9-3 / 18                                    pubyear: 1988

    5) Airborne infrared spectroscopy of ionized      copies: 1 (SHELVES)
       McCarthy, John Franc                               at: MAIN
       A 20-3 / 10                                   pubyear: 1980

    6) IR. Theory and practice of infrared spectr     copies: 1 (SHELVES)
       Alpert, Nelson L.                                  at: MAIN and others
       PH 13-2 / 2                                   pubyear: 1973
50d (c) Sirsi Corporation                                        PAGE 1
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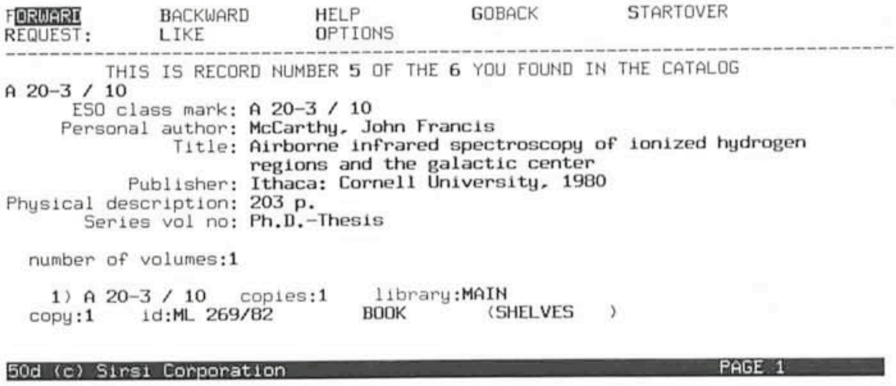
Figure 5: *Choosing item 5 of 6 retrieved items.*



```
FORWARD      BACKWARD      HELP          GOBACK        STARTOVER
REQUEST:     LIKE          OPTIONS
------------------------------------------------------------------------------
           THIS IS RECORD NUMBER 5 OF THE 6 YOU FOUND IN THE CATALOG
A 20-3 / 10
      ESO class mark: A 20-3 / 10
     Personal author: McCarthy, John Francis
               Title: Airborne infrared spectroscopy of ionized hydrogen
                      regions and the galactic center
           Publisher: Ithaca: Cornell University, 1980
Physical description: 203 p.
       Series vol no: Ph.D.-Thesis

  number of volumes:1

    1) A 20-3 / 10   copies:1    library:MAIN
  copy:1     id:ML 269/82        BOOK        (SHELVES    )

50d (c) Sirsi Corporation                                        PAGE 1
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Figure 6: *Displaying item 5 in full.*

books are also retrievable via the normal library catalogue.

In addition, the catalogue will inform you about the latest issues of journals that have been received in one of the libraries.

Placing Reservations

If a required item is on loan at the moment, users might want to place a reservation on it. For this purpose, a REQUEST-option will be available which reserves an item instantaneously. The user will be notified as soon as the item has been returned to the library.

Using Research Results

If you don't need a retrieved item right now, but would like to keep the reference, it will be possible to print search results or send and file to your account for further usage.

Circulation

The present circulation system in the ESO-Libraries is not at all sufficient. It is time-intensive and inefficient for the users as well as for the librarians. To tell you the truth, it doesn't even provide us with the necessary data we would need to control circulation actions or chase missing issues. How does it work at the moment?

- Borrowers have to sign book cards if they want to lend a book. One of these cards will be put in the shelf to replace the book. If the card is removed from there, it is very difficult to trace to whom an item has been issued
- Enquiries of patrons regarding a complete list of books they have borrowed cannot be answered easily
- Renewals require the filling out again of all relevant book cards
- There is no control over which items are borrowed and for how long.

Users usually consider the circulation process to be an interruption of their work, and taking into account the several steps they have to follow at present, we understand their annoyance. Therefore, improving this situation had a high priority when we compared the library systems that are currently on the market. We want to turn the circulation activity into a process as smooth and painless as possible. Probably in the course of next year, all items will be equipped with barcode labels, and barcode readers will be attached to terminals in the libraries. Reading in item and user numbers will then be enough to circulate an item.

Of course, these changes won't save us from missing one book or another, because a user has taken it out of the library without checking it out properly – either by mistake or willingly. There won't be a robot crawling through the offices every morning, trying to find hidden books that ought to be in the library, nowhere else. A library that is open 24 hours a day has to count on the honesty and solidarity of the users. But maybe our users will like the new system so much that they enjoy the fun of using it and no longer feel that having to behave according to the rules causes them pain …

Still a Long Way to Go

We have achieved a lot in a relatively short time during the last months. Nevertheless, there is still a long way to go before the database is completed and finally accessible for everybody. We hope to finish retrospective conversion in the first half of next year, and further tasks, like creating user records, converting the current circulation management into machine-readable form, assigning special locations to particular items, etc. can easily be foreseen.

Until now, we have had to cope only with rather small difficulties, but according to the experience of several colleagues, it is quite normal to have to

SEST Users Meeting

The third SEST Users Meeting will be held in Onsala, Sweden, on 18–19 March 1993. Those wishing to attend should write to:

SEST Users Meeting
Onsala Space Observatory
S-43900 Onsala
Sweden

face major problems in the course of changing to automated library management. Of course, we are sticking to "positive thinking" and are keeping our fingers crossed that the going won't get extremely tough. However, it will be worthwhile to concentrate forces on this project in order to make life easier and much more efficient for both librarians and library users.

On October 28, a three-child delegation walked into the Director General's office to talk about the Children's Christmas Party. Of the concessions they pressed for, the request to invite Saint Nicolas to participate in person was foremost and the DG was left little choice but to grant this.

Judging by the picture, showing from left to right Cornee Ravensbergen, Harry van der Laan, Nadja Dekker and Adriaan van Dijsseldonk, all were happy with the agreement reached! Photo: H.-H. Heyer

"Exploring the Universe" from the Desert Gate

Antofagasta describes itself as "Gate to the Desert, Window on the Sea". For 17 days a window on the Universe was opened for the population as ESO in collaboration with the University of Antofagasta opened its travelling exhibition at the foyer of the Municipal Theatre right in the centre of the town.

Days before the opening, a group of enthusiastic students from the University of Antofagasta went through an astronomy crash-course including a visit to La Silla, ending with an "exam" conducted by the Head of the La Silla Astronomy group, Jorge Melnick. The students then took over the job as exhibition guides.

The ESO exhibition occupied two floors, one devoted to astronomy and one to ESO and its activities, including a presentation of the VLT and Paranal. It is the first time that the ambitious VLT plans were presented to the local population, and the ESO exhibition was met by a wide-spread interest. This was evident already at a well-attended press conference, which was held in the morning of October 27, the day of the inauguration. Jorge Melnick, Patrice Bouchet and ESO Administrator Armelle Cabillic answered a whole range of questions.

At the inauguration, a large number of invited guests, including the Intendente for the 2nd region, Don Blas Espinoza, and the Mayor of Antofagasta, Pedro Araya Ortiz, listened to speeches by Don Jorge Peralta Hidalgo, Rector of the University, and Jorge Melnick, after which they enjoyed a guided tour through the exhibition, with the small corps of student-guides demonstrating their skills in a very convincing way.

After being dismantled in Antofagasta, the ESO travelling exhibition will take a small break for the (southern) summer. However, ESO has received a number of invitations for new exhibitions, among others from the University of Concepción.

C. MADSEN, ESO

Figure 1: *From the Antofagasta press conference: Jorge Melnick presents the VLT project to the press.*

Figure 2: *A student explains the wonders of the Milky Way to the invited guests at the inauguration.*

IC 1396

The southern part of the large diffuse nebula IC 1396 in the northern Milky Way band in the constellation Cepheus is full of dark and dense areas where stars are now being born. The 6th-magnitude star HR 8281 near the centre is of the hot O6-type; it is also a visual double star. The area is about 13° North-East of the well-known North America Nebula. This masked and enhanced monochrome reproduction was made at the photographic laboratories at the ESO Headquarters from a blue-sensitive plate (IIIa-J emulsion) obtained with the 48-inch Oshin telescope at Palomar for the Second Palomar Survey, now being reproduced at ESO. Photographic work by H.-H. Heyer, ESO.

ESO in Milan

Some Notes on the Assembly of an ESO Exhibition

The attentive reader of the *Messenger* may have noticed over the past years some articles dealing with the travelling ESO exhibition. Most recently, on September 21, 1992, our exhibition was opened at the Museo Nazionale della Scienzia e della Tecnica in Milan, Italy. This time we would like to tell you how the assembly of an exhibition is done. Few people realize how much time and work is needed to put together a 200 m^2 exhibition. As usual it begins five days prior to the official opening ceremony.

Day 1: The Material Arrives

The most important thing on this day is to find the lost expo! This may sound somewhat strange, but experience has shown that, for various reasons, the expo lorry carrying all the exhibition material from Munich to the exhibition site is almost always delayed. After a lot of telephone calls it soon becomes known that the lorry neither got stuck in a traffic jam nor had to fight its way through an endless maze of one-way streets but had been subject to a very thorough customs control at the Austrian-Italian border. Finally it arrives at the museum and thanks to the perfect equipment and efficient work of the museum people, more than a dozen heavy and bulky boxes are unloaded in less than two hours. They are then transported to the exhibition hall where a preliminary check of the material is the last action of that day. Fortunately, there seems to be no damage.

Days 2 and 3: the Exhibition Begins to Take Shape

In the morning of the second day we begin to unpack the many crates. Soon the enormous volume of photos, panels, light boxes and other material spreads on the floor and threatens to create a real mess. Order is now required! At this stage the work changes from the transport of bulky and dirty boxes to the careful handling of fragile exhibition material. Meticulously following the careful assembly plans which have been worked out before at ESO in Munich, the exhibition bottom panels are built up. Thanks to the skillful and friendly museum staff this work progresses rapidly. In the late evening of the third day the earlier disorder has given way to some system and the exhibition is now, at least what concerns the larger elements, approaching the final shape.

Day 4: the Day of "First Light"

Although many exhibition sites have their own system of illumination, the ESO stand uses its own, specially designed lamps to give the right ambience. Moreover, certain elements like the Milky Way panorama and sets for video presentation must be connected to the power net. Soon the house electrician realizes that three things are required: many metres of additional cable, larger fuses and, most of all, more time. In view of the many expected visitors, electrical safety requirements must be

Figure 1: *Press conference at the opening of the ESO Exhibition in the Museo Nazionale della Scienzia e della Tecnica, Milan, on September 21, 1992. From left to right at the table: Prof. P. Tucci, Director of the Museum, Mr. de Mattei, Chairman of the Board of Directors of the Museum, Prof. H. van der Laan, ESO Director General, Prof. G. Setti, Director of the Institute of Radioastronomy, Bologna, and Prof. G. Chincarini, Director of Milan Astronomical Observatory (Brera).*

Figure 2: *At the opening of the ESO Exhibition in Milan: from left to right: P. Tucci, H. van der Laan, G. Setti, G. Chincarini.*

scrupulously fulfilled. The work progresses slowly and one by one the many cables are connected and disappear behind the panels. Finally, just before sunset the electrician finishes with his work and we have the "first light".

Day 5: Fine Tuning and Growing Excitement

The last day before the opening is the most important for the expo team. It includes a thorough control of all elements, small changes in the basic layout due to requirements of the hall and the preparation of information material for the visitors. Again the collaboration is excellent and at the end of this day all the persons who worked on the exhibition have one common thought: the anticipation of the visitors' reaction!

In the evening, the ESO Milan exhibition is opened in the presence of high city officials, the Board of the Museum, the ESO Director General and more than 200 invited guests. A press conference is held in the ball-room of a full-size model of the central section of a passenger ship. Speeches are given and questions are asked. Finally, the traditional walk through the exhibition takes place. Few of the participants may be aware of the stress of the past five days!

H. ZODET, ESO

NEW ESO PUBLICATION

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Professor Lodewijk Woltjer Elected to the French Academy of Sciences

Professor Lodewijk Woltjer, Director General of ESO (1975 – 1987), has just been elected Associate Foreign Member of the French Academy of Sciences, one of the five Academies which constitute l'Institut de France. Professor Woltjer is already a Corresponding Member of several other European Academies (The Netherlands, Belgium, UK) and a Member of the Royal Academy of Sweden.

This election honours first of all his scientific research from the study of the Supernova in the Crab Nebula to Quasars: his major role in the renaissance of European optical astronomy: assuming the leadership of ESO during 13 years, while ensuring the entry by Italy and Switzerland into this organization of unequalled scientific and technological potential; stimulating the conception of the VLT project and carrying through rapidly and efficiently the negotiations with the ESO member States which led to the decision to build the VLT, thereby re-establishing Europe's central position in optical astronomy which it had lost since the beginning of this century.

Professor Woltjer's international role as future President of the International Astronomical Union testifies to the wide-spread esteem in which he is held. The French Academy of Sciences has been very appreciative of the continued attention which Professor Woltjer has given to the collaboration with the authorities in various European countries, in particular in France, by providing wise and useful analysis of the desired evolution of national astronomy policies.

Professor Woltjer has also recently been nominated Chevalier de la Légion d'Honneur, the first grade of the supreme distinction which is granted by France.

P. LÉNA,
Member of the Academy of Sciences, France

Two European Astronomy Encounters in 1993

The situation in Europe is changing and so is European astronomy. The next years are bound to see an increasingly intense and fruitful interaction between astronomers from all regions of Europe.

The organizers of several astronomical meetings in Europe in 1993 are taking active measures aimed at promoting such connections, especially between West and East European astronomers. This is particularly true for two meetings which will be held in consecutive weeks in the second half of August 1993 and at a short geographical distance. This may induce some astronomers to participate in both and save some travel costs. Support for local expenses is also being generated.

The next meeting of the European Astronomical Society (EAS) "Extragalactic Astronomy and Observational Cosmology" will take place in Toruň, Poland, from 18–21 August 1993. It is followed by IAU Symposium 161 "Astronomy from Wide-Field Imaging" in Potsdam near Berlin, Germany, from 23–27 August 1993.

For further information about the EAS meeting, please contact Richard Wielebinski (Chairman of SOC), MPI für Radioastronomie, Auf dem Hügel 69, D-5300 Bonn, Germany, or Jan Palouš, EAS Secretary, Astronomical Institute, Budečská 6, CS-12023 Prague 2, Czechoslovakia (e-mail: ASTDSS@CSEARN.bitnet). For the Wide-field meeting, the address is: Astrophysikalisches Institut Potsdam (IAU Symposium 161), An der Sternwarte 16, D-O-1591 Potsdam, Germany (e-mail: fri@babel.aip.wtza-berlin.de).

STAFF MOVEMENTS

Arrivals

Europe

AITKEN, George (GB), Technical Editor
JABLONKA, Pascale (F), Fellow
KOTILAINEN, Jari (SF), Fellow
TINNEY, Christopher (AUS), Fellow
ZIJLSTRA, Albert (NL), Fellow

Chile

ABBOTT, Timothy (GB), Fellow
DE BRUIN, Peter (S), Associate (SEST)

Departures

Europe

JORISSEN, Alain (B), Fellow
LOUSTALOT, Florence (F), Secretary to the Head of Administration
MØLLER, Palle (DK), Associate
PADOVANI, Paolo (I), Fellow
PELETIER, Reynier (NL), Fellow
SCHWEMMER, Erika (D), Administrative Clerk (Personnel)

PROFILE OF AN ESO KEY PROGRAMME

Standard Stars for the Infrared Space Observatory, ISO

N.S. VAN DER BLIEK[1], P. BOUCHET[2], H.J. HABING[1], M. JOURDAIN DE MUIZON[3,1], D. E. BLACKWELL[4], B. GUSTAFSSON[5], P. L. HAMMERSLEY[6], M.F. KESSLER[7], T.L. LIM[8], J. MANFROID[9], L. METCALFE[7], A. SALAMA[7]

[1]Leiden Observatory, the Netherlands; [2] ESO, La Silla; [3]Paris Observatory, France; [4] University of Oxford, England; [5]Uppsala Observatory, Sweden; [6]IAC, Tenerife, Spain; [7]ESA-ESTEC, The Netherlands; [8]Imperial College, London, England; [9]Institut d'Astrophysique de Liège, Belgium

The Infrared Space Observatory (ISO) is a European Space Agency (ESA) satellite to be launched in 1995. Operating at wavelengths ranging from 2.5 to 200 μm (Kessler, 1992), ISO will be a unique facility with which to explore the universe. Its targets will range from objects in the solar system, at one extreme, to distant extragalactic sources, at the other extreme. ISO will operate as an observatory with 65% of its observing time open to the general astronomical community. Observations will be selected by proposal submission and peer review.

The satellite will carry on board a 60-cm telescope and four scientific instruments, mounted inside a 2300-litre superfluid Helium cryostat and operating at a temperature of around 3 K. The instruments are:

1. ISOCAM, a two-channel camera, operating between 2.5 and 17 μm, with a 32×32-element detector array in each channel;
2. ISOPHOT, a broad-band multi-filter photo-polarimeter, covering the wavelengths between 2 and 200 μm, with a low-resolution spectrometer, covering the wavelength ranges 2.5 to 5 μm and 6 to 12 μm;
3. SWS, the short wavelength spectrometer, offering resolutions in the range 1000 to 20,000, for wavelengths between 2.4 and 44 μm;
4. LWS, the long wavelength spectrometer, offering resolutions in the range 100 to 10,000, for wavelengths between 45 and 180 μm.

These instruments are being built by four independent consortia from ESA member States, using national funding. ESA is responsible for the development and launch of the satellite, and for the observatory operations, which end when the liquid Helium cryogen is exhausted, i.e. after a baseline lifetime of at least 18 months.

One of the major concerns for such a mission is the calibration of the instruments and thus of the scientific data products. In addition to the pre-launch on-ground calibration and characterization of the instruments, the observatory must be calibrated in-flight. This involves the use both of internal calibration sources and a range of astronomical reference sources (i.e. stars and asteroids for the photometric calibration and planetary nebulae or HII regions for the spectroscopic calibration).

A full description of the plans for the in-flight calibration of the ISO instruments can be found in the "ISO In Orbit Calibration Requirements Document", which is regularly updated by ESA in consultation with the instrument consortia.

Stars as Calibrators, the ESO Key Programme

The most suitable sources for the photometric calibration of ISOCAM and the shorter wavelength region of ISOPHOT are stars with well-known monochromatic fluxes. Stars can also be used as photometric standards for SWS and for the short wavelength region of LWS, and for correlating SWS and LWS spectra. However, a homogeneous set of standard stars suitable for wavelengths up to at least 50 μm does not exist!

The ESO Key Programme, "Infrared Standards for ISO", is a first step towards the setting up of such a system of standard stars.

In order to make it possible to use stars as calibrators up to these wavelengths, their far-infrared fluxes must be known, on the basis of photometric and spectroscopic data obtained from the ground in combination with stellar model atmospheres. The aim of this Key Programme is to obtain near-infrared (NIR) and mid-infrared (MIR, at 10 and 20 μm) photometric data and NIR spectroscopic data of the stars selected in the southern hemisphere. Similar efforts are being undertaken in the northern hemisphere by the IAC (Tenerife) and Imperial College (London). The project, as a whole, runs under auspices of the ISO Ground Based Preparatory Programme working group (Jourdain de Muizon and Habing, 1992), which was formed on the initiative of the ISO Science Team. This working group not only initiated the observational programmes, but also established a collaboration with Blackwell's group (Oxford) and with Gustafsson's group (Uppsala) to carry out the theoretical part of the project: determining fundamental parameters of the stars and modeling their far-infrared spectra.

The goal of the working group is to deliver a database of standard stars and fluxes to the ISO Science Operations Team well before the launch of ISO.

Selecting the Stars

For an efficient calibration of observations by ISO, i.e. to minimize the slewing time of the telescope, there should be at least 1 standard star per hundred square degrees. In other words, the set of standard stars for ISO has to contain at least 400 stars, evenly spread over the sky.

In fact, several conditions have to be met by a set of standard stars for ISO. Since they will be used as standards for different instruments of ISO, the stars should cover a wide range of magnitudes as well as a wide range of spectral types. In summary, the selected stars should be:

1. non variable stars;
2. single stars;
3. stars without an infrared excess;
4. brighter than $K = 12$, and fainter than $K = 0$;
5. evenly distributed over spectral type and magnitude;
6. homogeneously spread over the sky.

The ESO Key Programme covers the observations for the southern hemisphere. We selected stars from the infrared standard star lists of ESO (Bouchet et al., 1991), SAAO (Carter, 1990), AAO (Allen and Cragg, 1983), and CTIO (Elias and Frogel, 1983). We extended the sample by selecting stars from the Bright Star Catalogue (Hoffleit, 1982) and the Henry Draper Catalogue. We used both catalogues and the Hipparcos Input Catalogue to discard multiple and variable stars. In addition, we used the IRAS catalogue to check that the spectra of the selected stars do not show an infrared excess. The sample contains 300 stars (see Fig. 1), of

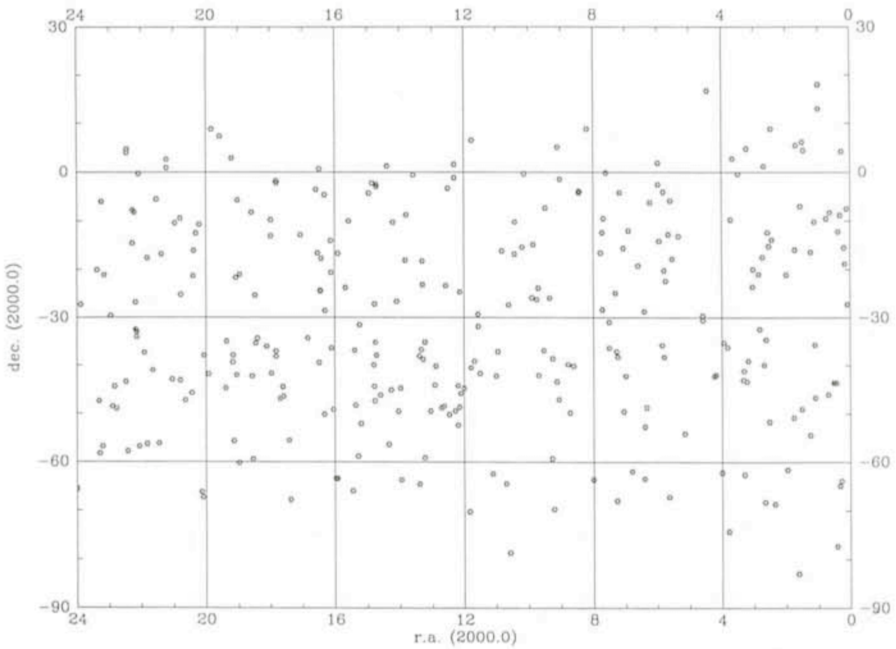

Figure 1: *Distribution of the stars over the southern hemisphere. In the present sample only very few stars have declinations smaller than 75°. We will therefore add some stars to the sample which are located in the polar region.*

which the 200 most suitable stars will be used as southern standard stars for ISO.

Photometry

For the entire set of stars we are acquiring J,H,K and L broad-band photometry as well as narrow-band NIR photometry. The narrow-band filters are CVF filters centred on 1.58 μm (H band), 2.16 μm (Brγ), 2.22 μm (K band), 2.29 μm (CO) and 3.70 μm (L band). The use of such narrow-band filters improves the accuracy of the photometry in two ways: 1. the narrow-band filters have pass-bands well within the atmospheric windows: their profiles are not defined by the edges of the atmospheric windows, and are therefore not changed by variations in the atmospheric transparency; 2. atmospheric extinction is colour dependent: narrow-band measures will be less affected by extinction variation than broad-band measures. Furthermore, the theoretical interpretation of narrow-band photometric data is more straightforward.

Additionally, we are obtaining MIR photometry at 10 and 20 μm for the brightest stars ($L \leq 2$) of the sample. For 10-μm photometry we use the standard filters N1 ($\lambda_0 = 8.36$ μm; $\Delta\lambda = 0.85$ μm), N2 ($\lambda_0 = 9.67$ μm; $\Delta\lambda = 1.65$ μm), and N3 ($\lambda_0 = 12.89$ μm; $\Delta\lambda = 3.7$ μm). We will use these data to investigate the presence of SiO and SiC features in the spectra of these stars. The 20-μm photometry (Q0; $\lambda_0 = 18.56$ μm; $\Delta\lambda = 5.6$ μm) will be used to check the far-infrared fluxes as predicted by theoretical atmosphere models.

Clearly this key programme will yield several by-products, which are useful for ground-based work:

- the existing set of standard stars for broad-band NIR photometry will be extended with standard stars having K magnitudes of up to 12;
- a system of standard stars for narrow-band NIR photometry will be defined;
- a system of standard stars for MIR photometry at 10 and 20 μm will be set up.

We reduce the photometric data with IR SNOPY, a reduction programme available at La Silla. For the narrow-band NIR photometry and the MIR photometry this is a preliminary reduction only: the sets of standard stars first have to be established. Therefore we will redo the reduction, when all photometric data have been collected, using a "global method", namely the one developed by Manfroid (1985). This method skips entirely the colour-transformation problem, i.e., only zero points are computed, instead of complete colour transformations. The method is ideally suited for setting up a new photometric system. For a large data set this method provides accuracies better than 0.01 mag for the broad-band NIR photometry, and 0.005 mag for the narrow-band NIR photometry. For the MIR photometry accuracies better than 0.01 mag in N1 and N2, 0.02 in N3, and 0.05 at Q0 can be reached.

Table 1: *The Royal Standard Stars*

	Spectral type	RA (2000)	Dec (2000)
A-type stars			
HR2421, γ Gem, Alhena	A0IV	06 37 42.7	+16 23 57
HR2491, α CMa, Sirius	A1Vm	06 45 08.9	−16 42 58
HR3314, C Hya	A0V	08 25 39.6	−03 54 23
HR7069, 111 Her	A5III	18 47 01.2	+18 10 53
HR7557, α Aql, Altair	A7V	19 50 46.9	+08 52 06
Early F-type stars			
HR0740, σ Ceti	F4IV	02 32 05.1	−15 14 41
HR5570, 16 Lib	F0V	14 57 10.9	−04 20 47
HR7469, θ Cyg	F4V	19 36 26.4	+50 13 16
HR7936, ψ Cap	F4V	20 46 05.6	−25 16 16
Solar-type stars			
HR0098, β Hyi	G2IV	00 25 45.3	−77 15 16
HR0448	G2IV	01 33 42.8	−07 01 31
HR0509, τ Cet	G8V	01 44 04.0	−15 56 15
HR1101, 10 Tau	F9V	03 36 52.3	+00 24 06
HR1983, γ Lep	F6V	05 44 27.8	−22 26 54
HR4903	G1V	12 54 58.4	−44 09 07
HR4989	F7IV	13 14 14.7	−59 06 12
HR5996	G4IV-V	16 07 03.3	−14 04 16
Red Giants			
HR1136, δ Eri	K0IV	03 43 14.8	−09 45 48
HR1907, φ 2 Ori	K0IIIbCN-2	05 36 54.3	+09 17 26
HR2990, β Gem, Pollux	K0IIIb	07 45 18.9	+28 01 34
HR4232, ν Hya	K2III	10 49 37.4	−16 11 37
HR5340, α Boo, Arcturus	K1IIIbCN-1	14 15 39.6	+19 10 57

Spectroscopy

Up to now we have obtained full IRSPEC spectra in the J,H,K, and L bands for 30 stars of spectral type A to K. These spectra are of medium resolution ($\lambda/\Delta\lambda \simeq 2500$) and span the following wavelength regions: 1.05–1.35 μm, 1.54 – 1.75 μm, 2.05–2.40 μm and 3.45–4.05 μm. To cover these four atmospheric windows, a total of 63 IRSPEC spectra need to be taken for each star. They are the first complete stellar spectra taken in the J,H,K and L bands and they will provide new constraints on the modeling of stellar atmospheres. We reduce the spectra with MIDAS and routines especially developed for the reduction of IRSPEC data (see also the article by R. Gredel in this issue of the *Messenger*).

The "Royal Standard Stars"

The prediction of absolute fluxes of these standard stars will be subject to severe uncertainties in model atmospheres. These uncertainties, which may lead to systematic errors in the calibration of ISO fluxes of more than 10%, are in particular errors in fundamental parameters, in temperature structure and in continuous and molecular opacities. In order to get a handle on these uncertainties, we are studying the effects of perturbations of the above-mentioned parameters on the far infrared spectra of model atmospheres. To improve the calibration, we also will make a detailed comparison of observed and synthetic spectra and fluxes of a sample of stars, selected to be representative for the full set of standard stars. We selected 22 such stars, named "Royal Standard Stars": 5 A-type stars, 4 early F stars, 8 solar-type stars and 5 K giants (see Table 1). These Royal Standard Stars will serve as a basic set for checking the calibration of the entire sample of standard stars.

Fundamental Parameters, Model Atmospheres and Far IR Fluxes

We use the NIR photometry as input for the "Infrared Flux Method" (Blackwell, 1986) and determine the effective temperatures and angular diameters of the stars. Independently we shall determine effective temperatures and gravities of the stars by comparing the observed and theoretical infrared colours, as described by Bell and Gustafsson (1989). To be able to compare the NIR data obtained at ESO with theoretical infrared colours, we will extend the work by Bell and Gustafsson for both the ESO J,H,K and L filters and the narrow-band NIR filters, described before.

We will use the fundamental parameters as input for model atmospheres: recent versions of the Kurucz models (Kurucz, 1991) for the hotter stars, and recent models from the Uppsala model atmosphere codes (updated versions of Gustafsson et al., 1975, with the Kurucz [1991] atomic line lists implemented) for the cooler stars. We will extend model atmosphere codes into the infrared, and use them in combination with the NIR data to predict infrared fluxes for the complete set of standard stars. The stars with $K > 6$ will be used as a standard system for the short wavelength range of ISO, up to 20 μm. The stars with $K \leq 6$ will be used as calibrators up to at least 50 μm.

The aim of the project is to predict the infrared fluxes of the complete sample of stars, with accuracies better than 10% for flux densities ≥ 1 Jy and to compile a list of standard stars which are suitable for wavelengths up to 50 μm. The working group plans to deliver a database of standard stars and infrared fluxes to the ISO Science Operations Team well before the launch of ISO, presently scheduled for 1995.

Acknowledgements

We are very grateful to ESO and to the Max-Planck-Institut für Astronomie, represented by Professor Elsässer, for the numerous nights of observing time allocated to this programme. We would like to thank the infrared team at La Silla for their assistance during the observations, with our special thanks to Rolando Vega. We also thank C. Turon and D. Morin for helping us with the Hipparcos Input Catalogue before publication.

References

Allen, D.A., and Cragg, T.A., 1983. *MNRAS*, **203**, 777.

Bell, R.A. and Gustafsson, B., 1989. *MNRAS*, **236**, 653.

Blackwell, D.E., Booth, A.J., Petford, A.D., Leggett, S.K., Mountain, C.M. & Selby, M.J., 1986. *MNRAS*, **221**, 427.

Bouchet, P., Manfroid, J., Schmider, F.-X., 1991. *A&ASS*, **91**, 409.

Carter, B.S., 1990. *MNRAS*, **242**, 1.

Elias, J.H., Frogel, J.A., Hyland, A.R. and Jones, T.J., 1983. *ApJ*, **88**, 1027.

Gredel, R., 1992. *The Messenger*, **70,** 62.

Gustafsson, B., Bell, R.A., Eriksson, K., Nordlund, Å. 1975. *A&A*, **42**, 407.

Hoffleit, D., 1982. *The Bright Star Catalogue* (4th revised edition), Yale University Observatory, New Haven.

Salama, A. and Metcalfe, L., 1992. *ISO In Orbit Calibration Requirements Document:* ISO – SSD – 9003, Issue 1.0, 01-07-92.

Jourdain de Muizon, M., Habing, H.J., 1992. In *Infrared Astronomy with ISO*, eds. Th. Encrenaz and M.F. Kessler (New York: Nova Science), p. 129.

Kessler, M.F., 1992. In *Infrared Astronomy with ISO*, eds. Th. Encrenaz and M.F. Kessler (New York: Nova Science), p. 3.

Koornneef, J., 1983. *A&A*, **128**, 84.

Kurucz, R.L. 1991. In IAU Symp. 149: *The stellar populations of galaxies*, eds. B. Barbuy and A. Renzini (Dordrecht: Kluwer Academic Publishers), p. 225.

Manfroid, J. 1985. Habilit. Thesis, Université de Liège.

SUSI Discovers Proper Motion and Identifies Geminga

G.F. BIGNAMI[2,1], P.A. CARAVEOL[1] and S. MEREGHETTI[1]

[1]Istituto di Fisica Cosmica del CNR, Milano, Italy; [2]Dipartimento di Ingegneria Industriale, Università di Cassino, Cassino, Italy

Twenty years have gone by since the discovery of the γ-ray source 195+5, the first UGO (Unidentified Gamma Object) seen by the NASA SAS-2 satellite. These years have been characterized by an endless quest for an identification of this puzzling object first in the γ-ray domain, with the ESA COS-B satellite (1975–82), then in the X-ray domain, with the NASA Einstein Observatory (78–81) and ESA EXOSAT (83–86) missions, finally in the optical (1983–today) using all the big telescopes of the world. Unfortunately, every step down in energy cost a factor of 1000 in the source strength (see table) and, adjusting the observing time, we ended up with $\sim$1000 photons in each energy range.

Energetics

Name	ν	# photons	Obs. time	Flux erg/cm^2 sec
Geminga 1972--->	γ-ray	~1,000	80 days	2 10^{-9}
1 E 0630+178 1983--->	X-ray	800+200	10,000 sec	2 10^{-12}
G″ 1987--->	optical	1,600	few hours	3 10^{-16}
---------	radio 21 cm	-------	deep search	< 5 10^{-20}

While wading through the intricacies of multiwavelength astronomy, the source acquired its multi-language name GEMINGA, officially for GAmma source in GEMINi, in reality a pun from the Milanese argot[*], making Geminga the first celestial object named in a dialect.

The 90's found the strong gamma-ray source GEMINGA associated with 1E 0630+178, a peculiar X-ray source (Bignami et al., 1983), and (tentatively) with a very faint optical object G", first seen with the CFHT and confirmed with the ESO 3.6 (Bignami et al., 1987, 1988) and with the 5-m Palomar (Halpern and Tytler, 1988), where the γ-X association rested on the strong similarity with the Vela pulsar and the X-optical one on the peculiar colour of G". Geminga was supposed to be an isolated neutron star, since only this object could explain at once the strong γ emission and the faintness of the optical counterpart in spite of the X-ray emission. Back in 1983, we had also proposed that it ought to be very close, ~100 pc (Bignami, Caraveo, Lamb, 1983). All this was very reasonable but rested purely on astrophysical ideas, not on hard facts. During 1992, however, new γ-X and optical observations provided the facts needed to secure the identification of Geminga.

First came the discovery of the 237-msec periodicity in the ROSAT X-ray data (Halpern and Holt, 1992). The same periodicity was immediately found in the contemporary GRO/EGRET γ-ray data (Bertsch et al., 1992) and in the old archived COS-B data (Bignami and Caraveo, 1992) which, covering a long time span, provided the best estimate of the $\dot{P}$ = 1.099 10^{14} s/s. Apart from clinching the identification of Geminga with 1E 0630+178, this is what is needed to compute the parameters of the rotating neutron star responsible for the X/γ-ray emission. The magnetic field turns out to be 1.5 10^{12} G, a rather normal value, while the standard formula $\dot{E} = I\Omega\dot{\Omega}$ gives 3.2 10^{34} erg/sec for the overall rotational energy loss of the pulsar.

This brings up the matter of distance: from the value of $\dot{E}$ one can immediately derive an absolute upper limit to the distance, in the assumption that all $\dot{E}$ goes into γ-rays. This upper limit is ~300 parsecs, and for a γ-ray production efficiency of, e.g. 10^{-2} similar to that of PSR 0833-45 (see e.g. Bignami and Hermsen, 1982), this would imply that Geminga is about 30 pc from us. Thus Geminga could be the neutron star nearest to us and, given the high velocities normal for pulsars, a measure of the proper motion ($\mu = 0.2 \cdot v_{100} \cdot d^{-1}_{100}$ ″/yr, with v in units of 100 km/sec and d in units of 100 pc) was the next sensible thing to do, as suggested by Bignami and Caraveo (1992).

The ESO Director General granted for this project one NTT night which, thanks to J. Breysacher, was split into two halfs: one in November 92 and one in January 93. This arrangement turned out to be a very successful one and, on November 4–5, the Geminga field was observed, in service mode, by A. Smette. Ten SUSI V frames, of 15 minutes each, were secured under very good seeing conditions (0.6–0.8″). A. Moneti combined the images right away and FTPed the sum to Milano.

The resulting image was compared with two others of the same field, obtained respectively at the CFHT 3.5-m instrument in January 84 and at the ESO 3.6-m in January 87 (Bignami et al., 1987, 1988). Figure 1 shows a composite of the three images, where the 84 and 87 ones have been re-binned and tilted to match the scale and orientation of the ESO 92 frame. The motion of G″ to the NE is apparent, showing an 84–92 displacement of about 12 pixels, with the 87 data at the correct angle and position.

To assess the effect more quantitatively, and to exclude any possible systematic error, the positions of several faint stars, beside G″, were compared in the three frames used. The pixel positions of 19 faint objects were measured in each image, then, for each star, a mean position was computed, and deviations from this mean are plotted in Figure 2 in units of pixel (0.13″) for the X and Y axis. While the comparison objects appear to lie well within the centring errors (typically < 1 pixel) in each image, G″ stands quite apart showing a clear NE displacement.

Using as reference star positions extracted from the original Hubble Space Telescope Guide Star Catalogue, kindly supplied to us by D. Golombek, we have computed the coordinates of G″ at the three epochs. A linear fit to the derived coordinates gives the following components for the proper motion of G″

μ_α= 0.14″/y μ_δ=0.10″/y

and a total of μ = 0.17″/y ± 0.05″/y

The reported evidence for a large proper motion of G″ (m_v = 25.5) can only be interpreted in two ways: either the object is a solar-system body (asteroid, comet, whatnot), or it is a subluminous, truly faint star. The first possibility cannot be discarded lightly, in view of the low ecliptic latitude of Geminga. Strongly against it, however, are the extremely slow motion (for a solar-system body) at a large angle with the ecliptic plane and, of course, the low probability of the event, in view of the very small area considered.

Interpreting G″ as a star, for a displacement similar to that observed, one obtains a round distance figure of 100 pc for a velocity in the plane of the sky of 100 km/sec, not far from the mean for radio pulsars (see e.g. Lyne et al., 1982). At 100 pc, the object would have an M_v = 20.5, to be compared, e.g., with the Vela pulsar's 15, i.e. with an "under-luminosity" only comprehensible for a neutron star. Anything more luminous would have to be correspondingly more distant and thus faster. For comparison, the Vela pulsar, at an accepted distance of 450 pc, has been measured to have a proper motion of about 0.05″/y (Bignami and Caraveo, 1988; Bailes et al., 1989; Ogelman et al.; 1989) Late-type extreme subdwarfs with large transverse velocities and with absolute magnitudes as faint as M_v = 15 (Monet et al., 1992), could mimic the apparent magnitude, as well as proper motion, of G″ only for extreme velocity values. Moreover, this possibility, unlikely in view of the very small area considered, is definitely ruled out by the colour of G″. Altogether, no known object other than a neutron star can explain the properties of G″. It is thus unavoidable

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[*] Gh'è minga means "is not there" to most northern Italians.

to conclude that the observed motion is proof of the optical identification of Geminga, the neutron star nature of which is by now firmly established from the gamma/X-ray data.

Geminga then becomes the third neutron star identified in the optical, after the Crab and Vela pulsars. The LMC pulsar 0540-69, although definitely seen to pulsate at optical wavelengths (Middleditch et al., 1987), has so far only a probable identification through imaging (Caraveo et al., 1992a and b). Geminga is the first object discovered and identified through its gamma-ray emission and the first isolated neutron star studied without the help of radio astronomy, and is surely the prototype of a class whose properties are now open for a better understanding.

It may be of interest to speculate on the birthplace of Geminga, now that its direction of motion and angular velocity are known. If its age is really 370,000 years, as suggested by its period derivative value, the object comes from a point about 16 deg roughly to the SW of its present position. Such hypothetical birthplace appears to be well outside the boundaries of the Gemini constellation, so that the present name could not have been given at birth. In view of the small distance involved, it is probably difficult to search for a SN remnant which may now well include the Earth. But if Geminga was indeed generated in a SN event, it may be more interesting to speculate on the possible environmental effects of an event which would have liberated a huge amount of energy at 100 pc or so from the Earth.

As to the physical nature of the optical emission, the data presented above do not add information, except for the possible constraint on Geminga's absolute magnitude. As discussed in the literature, thermal as well as non thermal mechanisms may contribute to the emission, which could be pulsed at 237 msec, with a still unknown duty cycle. The period-luminosity dependence originally proposed by Pacini (1971), and rediscussed more recently (Pacini and Salvati, 1987), can be applied, assuming

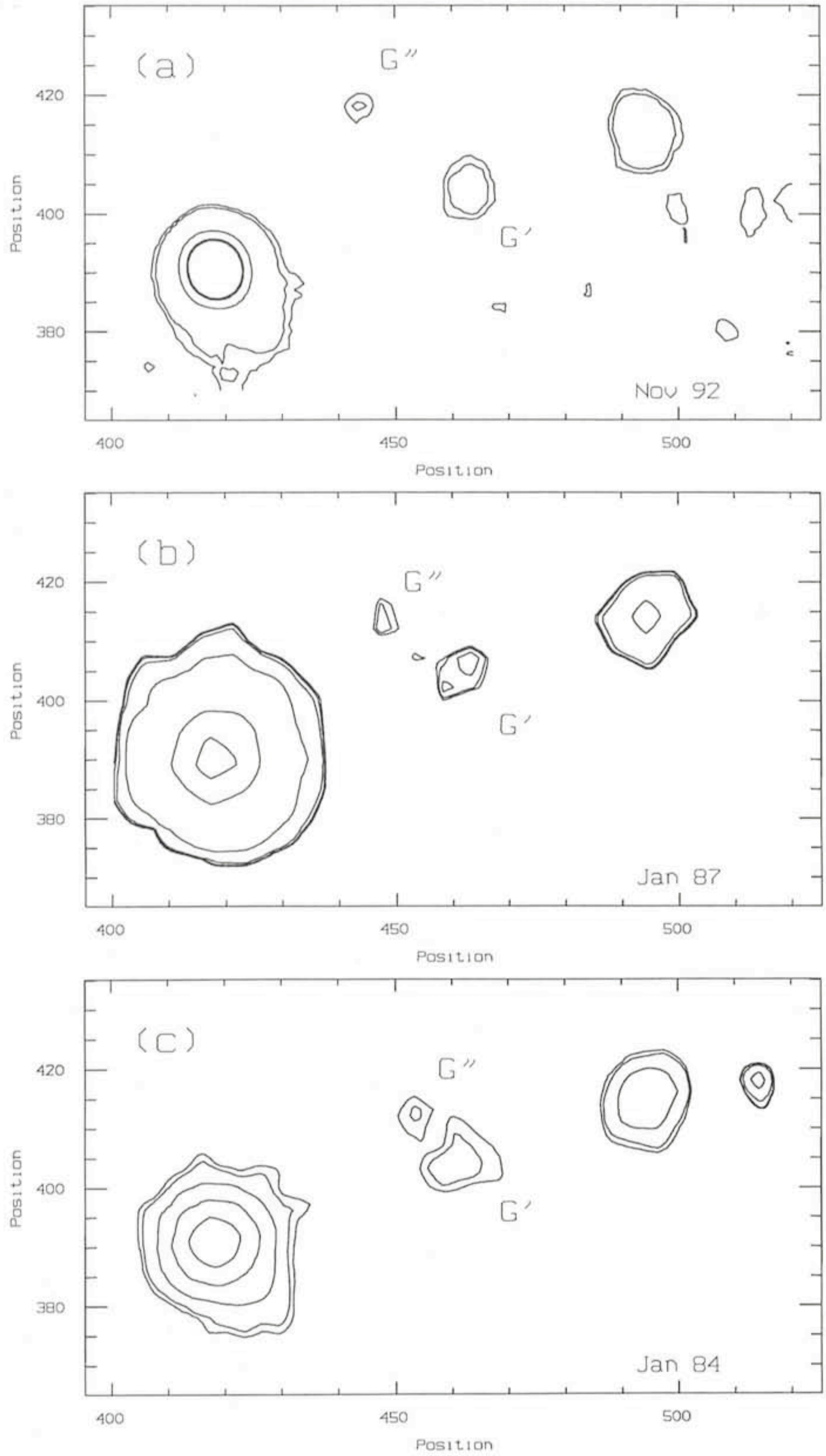

Figure 1: *Contour plots of the three data sets used, showing the motion of G″ over ~8.8 years. The overall displacement between the first and the last observation is ~12 SUSI pixel (0.13″ each), with the 87 data set showing G″ at an intermediate position.*

(a) November 4, 1992 data. Stack of 10 V exposures of 15 min each, taken at the ESO NTT with SUSI. Seeing conditions were very good (0.6-0.8″). G″ is detected at: R.A. (1950) = 6h 30m 59.15s; Decl. (1950) = 17° 48′ 33.6″ ± 0.16″. The orientation is roughly NE (an eastward tilt of ~3° is present but has not been corrected for to preserve the excellent quality of the image).

(b) January 28, 1987 data. Stack of 8 V exposures of 15 min each, taken at the ESO 3.6-m equipped with EFOSC (pixel size 0.675″). Seeing conditions were mediocre ~1.6″. The original data have been rebinned and tilted to match the SUSI field. The best position of G″ is R.A. (1950) = 6h 30m 59.10s; Decl. (1950) = 17° 48′ 33.0″±0.68″.

(c) January 7, 1984 data. Stack of 12 r exposures of 15 min each, taken under good seeing conditions (0.9″) at the CFHT. The original data (with a pixel size of 0.412″) have been rebinned and tilted to match the SUSI field. G″ was seen for the first time in this observation (Bignami et al., 1987) and its position is: R.A. (1950) = 6h 30m 59.06s; Decl. (1950) = 17° 48′ 32.7″± 0.46″

All the above coordinates have been computed in the original (not rebinned) data. The quoted uncertainties take into account the r.m.s. of the astrometry fit (0.10″, 0.12″, and 0.19″, respectively in the 1992, 1987 and 1984 data) and the error in the centring of G″ (~1 pixel in each data set).

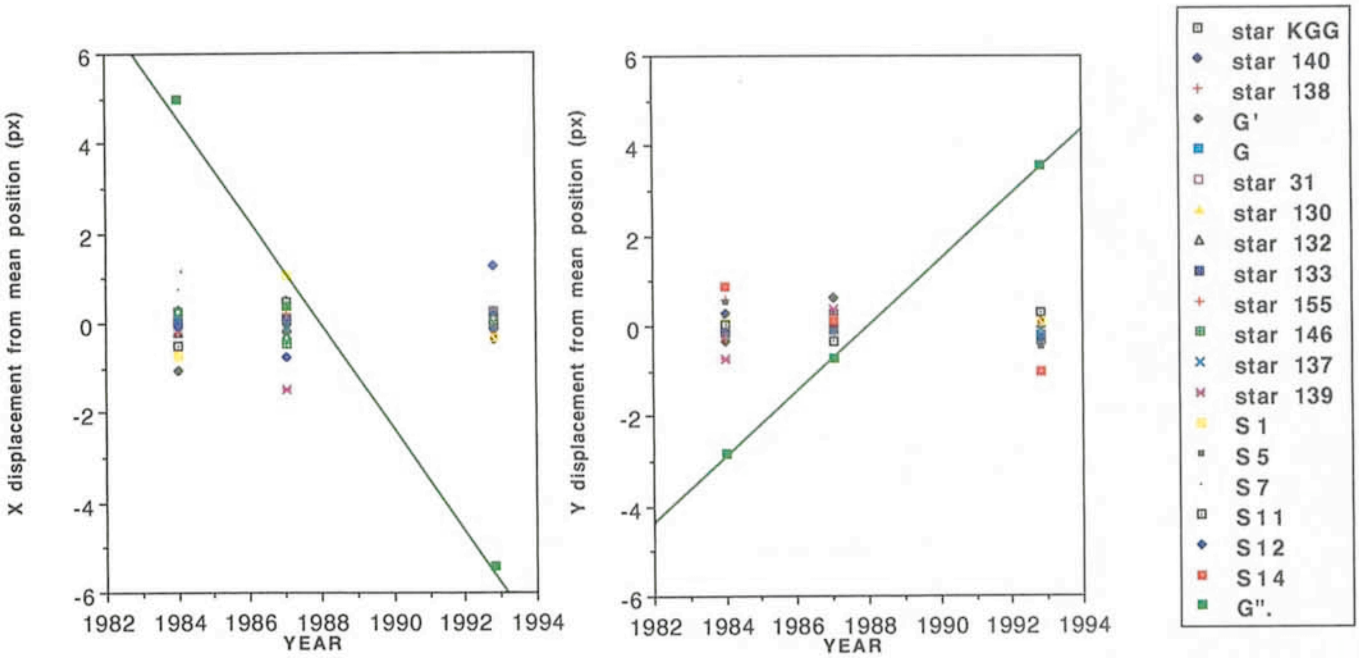

Figure 2: *X and Y displacements (in units of 0.13" pixels) from the mean position of G" together with 19 faint comparison objects. These are stars G, G', 31, 130, 132, 133, 137, 138, 139, 140, 146, and 155 (following the numbering given in Halpern and Tytler, 1988), plus other fainter ones visible in our three data sets. For each object, the positions obtained in the three frames were averaged and the three X and Y deviations from such a mean were computed and plotted in a and b.*
No systematic motion is present for the comparison objects, whose deviations appear to lie well within the centring errors (typically < 1 pixel) in each image.
G" (■) stands quite apart showing a clear NE displacement. The linear fits to the X and Y displacements of G" from the mean are also shown.

for Geminga an optical duty cycle similar to that of the Vela pulsar, as has been seen to be the case at higher energies. This yields an M_V ~28 which would place Geminga at ~ 3 pc.

The observed motion of G" could also have a bearing in explaining some of the difficulties encountered recently with the timing parameters of the object (see IAU Circ 5649). In particular, the second derivative of the period, when computed over a long time history to include both GRO and COS-B data (1991-1975), might be affected not only by period glitches, but also by a different position.

What next? The parallax measurement (e.g. 0.02" for 100 pc) is then the next challenge awaiting the Geminga aficionados.

Director Discretionary time has been granted for the observation of Geminga with the Planetary Camera on the HST. The observation is planned for December, with the purpose of pinpointing the position of G" to the best possible accuracy allowed by the current PSF. Repeating such measurements six months apart, something which cannot be easily done from the ground, might conceivably lead to a parallax measurements, thus also bringing to an end the distance problem.

So far, 1992 has been a magic year for the understanding of Geminga and December should bring more crucial data.

According to Trimble (1991), 20 years are not an unreasonable time between the discovery and the understanding of an astrophysical phenomenon. Are we at the end of our quest?

References

Bailes M., Manchester R.N., Kesteven, M.J., Norris R.P., and Reynolds J.E. *Ap.J.* **343**, L53 (1989),

Bertsch et al. *Nature* **357**, 306 (1992).

Bignami, G.F. and Hermsen W., *Ann. Rev. Astr. Ap.* **21**, 67 (1983).

Bignami, G.F., Caraveo, P.A., Lamb, R.C. *Ap. J. Lett.* **272**, L9 (1983).

Bignami, G.F., Caraveo, P.A., Paul, J.A., Salotti, L. and Vigroux, L. *Ap.J.* **319**, 359 (1987).

Bignami, G.F., Caraveo., P.A. Paul J.A. *Astr. Ap.* **202**, L1 (1988).

Bignami, G.F., Caraveo., P.A. *Ap.J. Lett* **325**, L5 (1988).

Bignami, G.F. and Caraveo P.A. *Nature* **357**, 287 (1992).

Caraveo P.A., Bignami, G.F., Mereghetti S., Mombelli M. *Ap.J. Lett* **395**, L103 (1992a).

Caraveo P.A., Bignami, G.F., Mereghetti S. Mombelli M. *The Messenger, No. 68, 30 (1992b).*

Halpern, J.H. and Tytler D. Ap.J., **330**, 201 (1988).

Halpern, J.P. and Holt S.S., *Nature* **357**, 222 (1992).

Lyne A. G., Anderson B., Salter M.J. *M.N.R.A.S.* **201**, 503 (1982).

Middleditch, J., Pennypacker, C.R. and Burns, M.S. *Ap. J.* **315**, 142 (1987).

Monet D.G. et al. *A.J.* **103**, 638 (1992).

Ogelman H., Koch-Miramond, L., Auriere M. *Ap.J.* **342**, L83 (1989).

Pacini, F., *Ap. J. Letters* **163**, L17 (1971).

Pacini, F., and Salvati, M., *Ap.J.* **321**, 447 (1987).

Trimble V. in "Gamma-Ray Bursts" eds. Ho, Epstein and Fenimore, p. 479 (1991).

New Object at the Edge of the Solar System

R. M. WEST and O. HAINAUT, ESO

A new object, which is probably a minor planet, has been found in the outer solar system. Although the available observations do not yet allow an accurate determination of the orbit, it appears that it is situated at the record distance of about 41 AU, i.e. just outside the orbit of Pluto.

Discovery and Follow-up Observations

The new object, which received the provisional designation *1992 QB1*, was

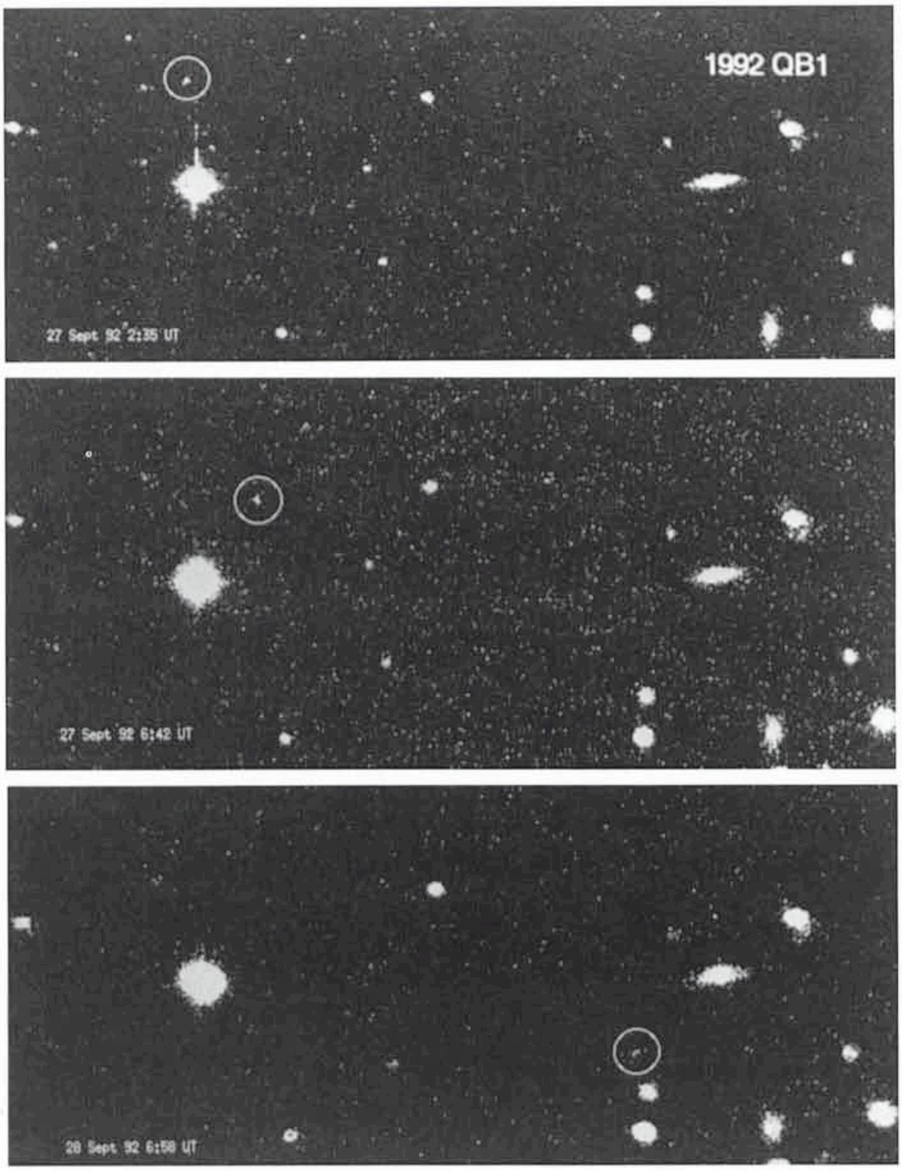

Figure 1: *A composite of three 5-min exposures of 1992 QB1, made on September 27 and 28, 1992, with EMMI at the ESO 3.5-m New Technology Telescope at La Silla by Alain Smette (ESO) and Christian Vanderriest (Observatoire de Meudon, Paris). The faint image of the 23-magnitude objects is indicated by circles. North is up and east is to the left.*

first seen by David Jewitt and Jane Luu, working with the University of Hawaii 2.2-metre telescope at Mauna Kea. They noticed the faint, moving star-like image on August 30, 1992 and again on the two following nights, in the constellation of Pisces. The brightness was about 23 and the colour was reddish.

An excellent extrapolation of the motion by Brian Marsden of the IAU Minor Planet Centre permitted renewed observations of 1992 QB1 after the full-moon period in mid-September. At La Silla, Alain Smette (ESO) and Christian Vanderriest (Observatoire de Meudon, France), obtained three EMMI CCD frames with the 3.5-m New Technology Telescope on September 27 and 28. These frames are shown in Figure 1. The brightness was about the same as at the time of the Hawaii observations, one month earlier.

These images were transmitted via the permanent satellite data link to the ESO Headquarters in Garching, where we measured the accurate positions of the slowly moving planet. With the help of the new positions, including some further ones from Hawaii, Brian Marsden was able to confirm the great distance of 1992 QB1.

Was 1992 QB1 Observed in 1930?

At one moment, it was thought that 1992 QB1 may possibly have been observed already in 1930, on a pair of photographic plates obtained at the Heidelberg Observatory in Germany. Brian Marsden found that it was possible to "connect" the measured position and motion of the once-observed object 1930 DV with those of 1992 QB1 in 1992. In that case the orbit would have been extremely eccentric and the heliocentric distance would have been only about 8 AU in 1930.

Lutz Schmadel of the Astronomisches Rechen-Institut in Heidelberg forwarded these plates to us. They were photographically enhanced in the ESO photographical laboratory in Garching by Hans-Hermann Heyer. Alas, a closer inspection then showed that on one plate, the image of "1930 DV" was pointlike and therefore did not move at all. It did not correspond to any object on the Palomar Atlas, but since there are other similar images in the vicinity, it is probably a plate fault. On the other plate of the pair, the "trail" was too faint to be measurable and could very well be the result of some slight emulsion unevenness. The reality of 1930 DV is therefore very doubtful and it would not be reasonable to try to identify it with 1992 QB1.

The Nature of 1992 QB1

On the assumption that 1992 QB1 moves in a circular orbit around the Sun, Brian Marsden estimates its distance from the Sun to be about 41 Astronomical Units (AU); this would correspond to a period of revolution around the Sun of 262 years. However, it cannot be entirely excluded that 1992 QB1 moves in an eccentric orbit and that the period is therefore significantly different. At this distance, and at this very slow rate of motion, it may take another couple of months, before accurate astrometric observations will be able to tell the difference.

Assuming a reasonable albedo (5 – 10%), the diameter of 1992 QB1 may be estimated at around 200 km. Although it is initially classified as a minor planet (the provisional designation shows that), it cannot at this moment be entirely excluded that the new object is an extremely distant comet that may have undergone an outburst, similar to that of Comet Halley in early 1991. It might even be the first ever observed object belonging to the hypothetical inner comet cloud, known as the Kuiper belt.

Whatever it may be, there is no doubt that 1992 QB1 is an extremely interesting object and that it will be intensively observed with large telescopes during the coming months, at ESO as well as at a few other observatories.

Latest News (December 4, 1992)

1992 QB1 was observed again with the NTT in late November. Pending further observations, it now looks as if small-to-moderate perihel distances can be ruled out but the orbit may still be Uranus-crossing.

Long-Term Stability in Classical Photometry

H. HENSBERGE, Koninklijke Sterrenwacht van België, Brussel, Belgium
J. MANFROID, Institut d'Astrophysique, Université de Liège, Belgium
C. STERKEN, Vrije Universiteit Brussel, Belgium

Introduction

Since October 1982, the Long-Term Photometry of Variables project (LT PV, see e.g. Sterken, 1983, Manfroid et al., 1991) is operational at ESO. Initially, several small photometric telescopes were used according to conditions of availability. Gradually, the need for one stable instrument was recognized, and today all observations are collected with the Danish 50-cm SAT. Among the large number of variable objects in the programme, there are some bright stars that are suspected of being microvariables on very long time-scales. It concerns magnetic CP stars for which there is evidence that the rotation period might be longer than 100 days, even as long as several tens of years. These stars show light variability that is modulated with the rotation period because the variation is due to their atmosphere's structure and composition which is not homogeneous over its surface. The amplitude of the light variations in the better known – somewhat faster rotating – CP stars is, in general, a few hundredths of a magnitude in the Strömgren photometric system. It is evident that the search for such variations over many years requires a differential approach, stable instrumentation, and a consistent observing and reduction procedure. This paper comments on our experience with stability of instrumentation and on the detection of light variations in γ Equulei, the slowest-rotating CP star known. According to magnetic observations (Mathys, 1990), this star is believed to rotate only once per century. Results on other CP stars, with periods ranging from 5 months to 10 years, are presented elsewhere (Hensberge, 1993).

Photometric Stability

Several recent papers refer to the loss of information resulting from the use of non-compatible versions ("clones", see Sterken, 1992) of a same photometric system and from the application of non-congruent transformation equations. Manfroid and Sterken (1992), for example, discern *conformity errors* and *reduction errors*. The former arise from the fact that the photometric systems have mutually different passbands, and that there is no way to evaluate the corrections needed to properly transform data from one system to another (see Sterken and Manfroid, 1987). The latter are of a purely methodological nature.

Manfroid (1992) demonstrates that conformity errors have a detrimental effect on the reddening vector, and consequently on the reddening-free indices, and that such is also the case when colour indices of composite objects (binaries) are transformed. Let us also point out that deviations from conformity will reflect in the derived extinction coefficients.

One must not forget that conformity errors are often unavoidable, since prescriptions of a purely practical origin (such as the availability of a given photometric system at La Silla) may force the investigators to rely on data coming from different such systems.

Reduction errors can be of two kinds: one class is due to the limited range of stellar types used in the colour-transformation procedure, and the other category are those errors that result when different transformation schemes are applied (see Manfroid et al., 1992). Reduction errors of the first category are typical for batches of data that are treated with a consistent method of reduction, as is the case in our long-term project. Some of the parameters in the reduction schemes have larger errors than others (for example, in Strömgren photometry the ratio of the uncertainties of the coefficients in the transformation equation of m_1 to the coefficient related to the $b-y$ transformation may amount to a factor of five), and the resulting errors are appreciably large for stars with extreme colour indices. Such effects are random shifts that affect all measurements of a given star by a same amount (during a specific observing run). Reduction errors of the second type are *extrapolation errors* that occur when different schemes of transformations are applied. Such situations typically occur when data, obtained and reduced by individual observers, are being taken from the literature and are combined in quasi-homogeneous datasets. These errors may be of the order of several tenths of a magnitude (see Manfroid et al. 1992) and appear as method-dependent shifts. They show up most clearly for stars having colour indices that fall outside the range of standard values, where the colour-transformation relations are necessarily extrapolated. Again, differential photometry does not help, since the effects do not show up for the comparison stars (if their colour indices belong to the range of indices of standard stars). Since usual schemes of colour transformation do not adequately represent the effects of interstellar reddening (Manfroid, 1992), the application of a variety of differing colour transformation schemes must lead to problems.

As a consequence, we limit the discussion hereafter to observations obtained within one single version of the Strömgren system, viz. to simultaneous uvby photometry obtained with the Danish 50-cm SAT telescope. From a careful analysis of non-differential magnitudes and colours in a large sample of standard stars and numerous reference (comparison) stars, it seems that the coefficients of the transformation equations to the standard system do not show long-term trends. We nevertheless prefer to present the lightcurves of CP stars in the instrumental system, because we wish to avoid loss of information in the case that the shape of the lightcurve is considerably wavelength-dependent. It is known that in such cases (see Manfroid, 1992, Hensberge, 1993) the transformation equations may induce changes of non-physical origin in the shape of the (transformed) lightcurves.

The only instrumental trend of long-term character has been detected at the level of the dead-time correction associated with the v passband. That such an effect was present, was readily apparent in our v-data (and in the colour indices involving the v passband), of couples of comparison stars of considerably differing magnitudes. The effect was confirmed when we checked the non-differential results on bright stars afterwards. The nominal value for the deadtime, $8.8 \; 10^{-8}$ s, changed at a rate of $1.7 \; 10^{-8}$ s per 1000 days, resulting in a change of about 35% over the last 5 years! An example of a spurious effect produced by this drift is shown in Figure 1, that illustrates the case for two constant comparison stars that have substantially different apparent magnitude.

Once this trend is taken out, the stability of the differential results is quite satisfactorily. Checks for presumably spurious long-term trends or instabi

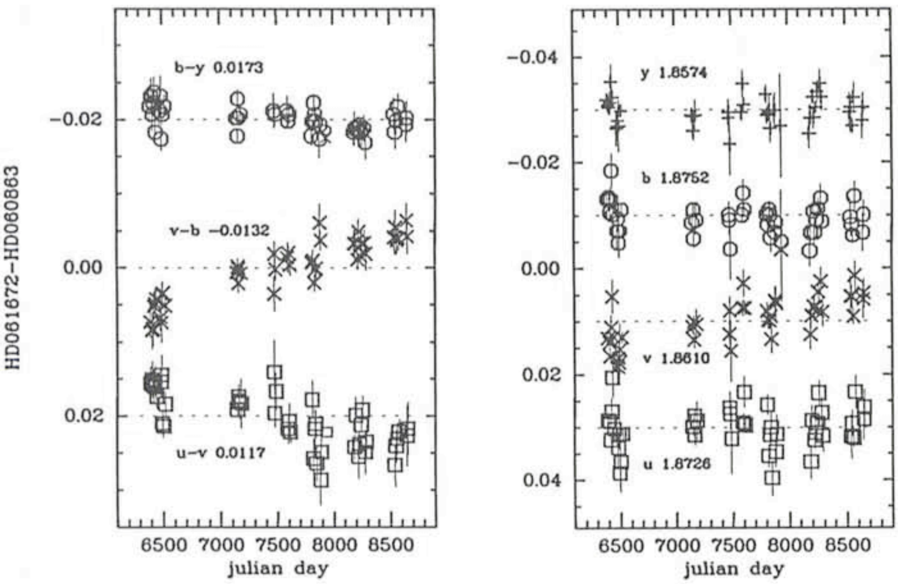

Figure 1: *Spurious effect produced by the drift in dead-time correction for the v-channel of the SAT telescope: differential photometry for two constant comparison stars of different brightness. The vertical scale is a relative scale; the mean magnitude and colour-index values are indicated.*

lities, over the 8 years covered, exclude effects exceeding a few thousands of a magnitude (it should be stressed, however, that comparison and programme stars were never very different in spectral type, the extreme case being the comparison between a late B and an early F-type star).

γ Equulei

γ Equ is an extreme sharp-lined late A star with a spectrum characterized by strong Sr lines and by a magnetic field with a strength of several kG. The literature on this star contains, from 1967 on, very different suggestions for the period of magnetic variations and light variations, including 9 days, 17.5 days, 10.5 months, almost 5 years, and 72 years (see references in Catalano and Renson, 1984). The discussed light variations, which are of very small amplitude, were – to our opinion – at best disputable or inconclusive. In addition, fast oscillations (period of about 12 minutes) have been detected (Kurtz, 1983) with an amplitude not exceeding 1 mmag. All the evidence on the magnetic field, collected from 1946 on at Lick, Mauna Kea, Tautenburg and La Silla Observatories (see Mathys, 1990), supports a very slow change of the integrated longitudinal component of the magnetic field with a polarity reversal around 1970–1971.

Now that a homogeneous set of photometric data becomes available in the LTPV project, we can deduce with confidence that the star gradually changes magnitude and colour on a time scale which is much longer than the time interval covered by our observations (see Fig. 2). The error bars refer to "internal error" estimates; there are indications that external errors are significantly larger (25%) only when u is involved.

The inferred rate of change is largest in the v passband (8 ± 0.6 mmag per 1000 days), a very common characteristic for late-A peculiar stars, but is also present in the other channels. Due to the simultaneous character of our photometry, the very small colour changes are detectable: in units of mmag per 1000 days they amount to 2 ± 0.4 in b−y, 4.5 ± 0.2 in v−b and −5 ± 0.7 in u−v. In spite of the caution to be taken when making comparisons with data from other sources, it is clear that the colours observed by Wolff and Morrison (1973) in 1963 and 1970–1971 are sufficiently similar to our results in order to suggest that these colour gradients most probably have changed during the two decades covered by the data.

Conclusions

Besides obvious disadvantages with respect to CCD photometry in applications in crowded fields or in fields with a complicated background, the relative simplicity of classical photomultiplier-based photometric equipment certainly has advantages in applications that rely on long-term stability requirements (though, it must be stressed, CCD systems may also prove to be very stable). Using small telescopes, and simple – but consistent – reduction efforts, the accuracy limits that are obtainable open interesting research possibilities in several fields demanding high-precision photometry over long time-intervals. The necessary condition, of course, is that one has access to the same instrumentation during the whole time interval covered by the project. The necessity for one or more observers to reside quasi-permanently on site is avoided by the elegant solution of central coordination of service observing for several such programmes inside one global project. The LTPV approach, applied at La Silla for more than a decade,

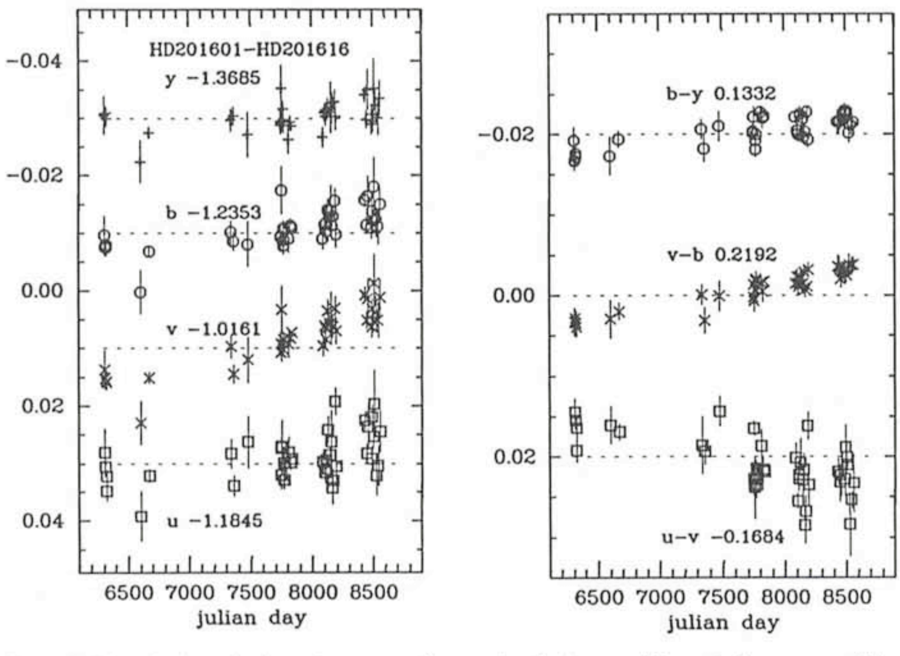

Figure 2: *Magnitude and colour changes on time scales that exceed the actual coverage of the LTPV project: differential photometry of γ Equ (HD 201601) relative to HD 201616. The vertical scale is a relative scale; the mean magnitude and colour-index values are indicated.*

not only widened the scope of photometric precision, it also yielded a considerable amount of new astrophysical discoveries combined with novel insights in handling of photometric data and a broader understanding of instrumental performance at an unprecedented high level of cost-effectiveness.

References

Catalano F., Renson P. 1984, *A&AS* **55**, 371.
Hensberge, H. 1993, in: Proc. IAU Coll. 138 *Peculiar versus normal phenomena in A-type and related stars*, eds. M. Dworetsky, F. Castelli; Kluwer Academic Publishers, Dordrecht (in press).
Kurtz, D. 1983, *MNRAS* **202**, 1.
Manfroid, J. 1992, *A&A* **260**, 517.
Manfroid, J., Sterken, C., Bruch, A., Burger, M., de Groot, M., Duerbeck, H.W., Duemmler, R., Figer, A., Hageman, T., Hensberge, H., Jorissen, A., Madejsky, R., Mandel, H., Ott, H.-A., Reitermann, A., Schulte-Ladbeck, R.E., Stahl, O., Steenman, H., vander Linden, D., Zickgraf, F.-J. 1991, *First Catalogue of Stars Measured in the Long-term Photometry of Variables Project (1982–1986)*, ESO Scientific Report No. 8.
Manfroid, J., Sterken, C. 1992, *A&A* **258**, 600.
Manfroid, J., Sterken, C., Gosset, E. 1992, *A&A* **264**, 345.
Mathys G. 1990, *A&A* **232**, 151.
Sterken, C. 1983, *The Messenger* **33**, 10.
Sterken, C., Manfroid, J. 1987, Proc. 27th Liège International Astrophysical Colloquium, 55.
Sterken, C. 1992, *Vistas in Astronomy* **35**, 139.
Wolff S.C., Morrison N.D. 1973, *PASP* **85**, 141.

The Contribution of Detailed Analyses of F, G and K Stars to the Knowledge of the Stellar Populations of the Galactic Disk

G. CAYREL DE STROBEL, Observatoire de Paris, Meudon, France

Introduction

Five subsystems of stars have been clearly identified in the Galaxy: the Halo, the Thick Disk, the Thin Disk, the Spiral Arms and the Galactic Bulge. The stars which populate the Halo are very old and are known also as Population II (Pop. II). Those of the Thick Disk are old stars, almost as old as the Halo stars, and are known as intermediate Pop. I stars. The stars of the Thin Disk, which are true Pop. I stars, may have any age between 0 and 10 Gy (10×10^9 years), or even more. The Thin Disk population may be split in "young" Thin Disk, and in "old" Thin Disk Pop I stars (Nissen and Schuster 1991). The youngest Pop. I stars are found in the Spiral Arms. In the Galactic Bulge exists the full span of populations and of stellar ages. The Halo and the Bulge are called the spheroidal stellar components of the Galaxy; their spatial distribution is strongly centrally concentrated, in contrast with the Disk and Spiral Arm populations.

The knowledge of the age, the kinematics, and the chemical composition of a star is essential for determining the subsystem to which the star belongs. Unfortunately, the age of a star is not an easy parameter to determine, too many assumptions on the internal structure and the state of evolution of the star must be made, before being able to attribute an age to a star. We are still arguing about the age of the oldest stars of the Halo, born soon after the Universe. The age of the oldest stars lies inside a bracket of at least 5 Gy (from 13 to 18 Gy). If we want to attribute a turn-off age to a star, the star must, first, be in its "turn-off" stage of evolution, and, second, must fit a reliable isochrone, constructed with the help of a grid of evolutionary models computed with a good input physics, and having very similar chemical composition (X, Y, Z), as that of the star to be dated.

The study of the chemical composition of stars belonging to different subsystems is of great importance, because the variation of metallicity as a function of space and time is a central problem for the knowledge of the chemical evolution of our Galaxy and of other galaxies.

Very interesting is the help we can derive from long-lived low-mass stars, evolving slowly, for the study of the chemical evolution of the Galaxy. Indeed, it is among late F, G and K stars, having effective temperatures between 6000 K and 4000 K, that evolution has not depleted the initial stellar populations of the Galaxy, and that the full span of stellar ages is still present. The extended convective zones of low-mass stars prevent the formation of peculiar abundances at their surface, with, however, the exception of lithium for some F stars and hotter G stars. Therefore, the abundances of the elements found in analysing in detail an atmosphere of a low-mass star give direct information about the chemical composition of the interstellar cloud out of which the star was formed.

In general, late F, G and K stars are used to study stellar populations, the abundance gradients across the Galactic Disk, the constraints on primordial nucleosynthesis imposed by the chemical composition of extremely metal deficient objects, the connection between kinematic and dynamic evolution of our Galaxy and of other galaxies. F, G and K stars have also another advantage: their spectra are easier to analyse than the spectra of hotter stars with broadened spectral lines and which require analyses based on Non-LTE (Local Thermodynamic Equilibrium) model atmosphere computations, and of cooler stars in which molecular bands become a serious problem.

We use as a metal abundance indicator, the well-known parameter:

$$[\mathrm{Fe/H}] = \log (\mathrm{Fe/H})^{*} - \log (\mathrm{Fe/H})$$

which represents the logarithmic difference between the relative abundance of iron with respect to hydrogen in the atmosphere of a star, and the relative abundance of iron with respect to hydrogen in a standard star. Following Gilmore and Reid (1983), Gilmore and Wyse (1985), Rich (1990), we define in Table 1 four abundance intervals Δ [Fe/H] constructed with stars belonging to different subsystems.

However, if these four population criteria are defined kinematically, and non-chemically, each of them has a spread in metallicity, and there is some overlapping in their metallicity distribution (Laird et al. 1989). The best way to differentiate a Halo from a Thick Disk star having the same [Fe/H] value, say, 1.2 dex, is the analysis of their galactic orbits. Indeed, both chemical composi-

Table 1: *Abundance intervals of F, G and K stars belonging to four different galactic subsystems:*

Halo (Pop II):	$-4.5 < [Fe/H] < -1.0$
Thick Disk (intermediate Pop. I):	$-1.0 < [Fe/H] < -0.4$
Thin Disk (Pop I):	$-0.4 < [Fe/H] < +0.25$
Bulge:	$-1.5 < [Fe/H] < +0.7$

tion and galactic orbits have to be taken into account to disentangle stellar populations (Nissen and Schuster 1991). The astrometric and kinematic properties of a given star play an important role in the recognition to which population this star belongs.

Hereafter, we would like to present and discuss some results we have obtained on the atmospheric parameters and, in particular, on the chemical composition, of F, G, and K stars belonging to the Thin and Thick Galactic Disk, located in the near solar neighbourhood, ($\pi < 25$ pc).

High Resolution, High S/N Spectroscopic Observations of Disk Stars in the Solar Neighbourhood and Corresponding Results

The solar neighbourhood is composed of a mixture of stars at different stages of evolution. A few of them are Pop. II stars, coming from the interpenetrating spheroidal component, but the majority are F, G, and K stars belonging to the Thin Disk population.

For astronomers interested in both high-resolution spectroscopic analyses and the chemical evolution of the Galaxy, the study of disk stars of different ages in the solar neighbourhood is interesting, because, owing to the proximity, and therefore the brightness of the objects, they can be observed with relatively small telescopes at high resolution and high S/N ratios.

Our observations of stars belonging to the Thick and Thin Disks are obtained by means of high resolution (between 40,000 and 80,000), high S/N (between 200 and 800), solid state spectroscopy (Reticon and CCD), mostly at the 1.4-m CAT of ESO, but also at the 3.6-m of CFHT, and at the 1.52-m of OHP. Our final aim is to establish for this sample of Disk stars a homogeneous set of results of chemical composition, effective temperature and state of evolution.

Prior to the discussion here is a short reminder of the methods we have used to derive such data rigorously.

The spectra of the programme stars are interpreted by a detailed differential curve of growth analysis. The theoretical equivalent widths of the spectral lines and the theoretical curve of growth of the analysed stellar spectra are computed using a grid of LTE model atmospheres, of various effective temperatures, gravities and metallicities, suitable for F, G and K dwarfs and subgiants, kindly provided by B. Gustafsson in 1981. The Sun (sky light or Moon) is adopted as comparison star. Departures from LTE in the atmospheres of the programme stars are not very disturbing, because, in solar-like stars, as those we are discussing, the atmospheric structure is similar to that of the Sun. Therefore, in a differential analysis with respect to the Sun, the Non-LTE departures in the analysed star and in the comparison star largely cancel out.

It is important to remark that reliable stellar abundance determinations are possible only if we have previously determined, with great care, the fundamental physical parameters of the star to be analysed: its effective temperature, surface gravity, microturbulence, rotational velocity, etc. For the knowledge of the chemical composition of a star, it is as important to improve the determination of T_{eff} and log g, as the model atmosphere computation.

The effective temperatures, T_{eff}, of a programme star is derived on purely spectroscopic grounds from the depth of its H_α wings (set at 4 Å from the H_α core) relative to the continuum, and/or from the observed ratio of the stellar spectrum to the sunlight spectrum near H_α as compared to computed ratios.

The gravity, log g, is determined from the ionization equilibrium.

The "microturbulence", ξ_t (km s^{-1}) is derived from an absolute curve of growth of the Sun with equivalent widths coming from the same observational material as that of the stars.

The chromospheric activity is qualitatively estimated from the central intensity of two lines of the Ca II triplet at 8550 Å.

The metal abundance is determined by matching equivalent widths in the observed spectrum of a programme star to those of a model computed with the most appropriate T_{eff}, log g, and ξ_t previously found for this star.

To ensure the differential character of the analysis, it is essential that the models used for all the programme stars, including the comparison star, in our case the Sun, come from one and the same grid of model atmospheres.

Having given the recipe of how to perform a reliable detailed spectroscopic analysis, we now present some of our research programmes and the subsequent results. These results are given in Table 2. They concern the gravity, the iron abundance, the bolometric magnitude, the effective temperature of the observed stars. We thought it useful to also add distance, kinematics, colour and spectral type results extracted from the literature. The last column of Table 2 indicates the observatory at which our observations have been made. In Table 2 the values attributed to the parallaxes of 16 Cyg A and B, and to those of HD 1835, HD 20630, and HD 76151 are not extracted from the Catalogue of Gliese (1969), but have been kindly sent to the author by C. Dahn in 1991.

F, G and K Well Separated Visual Binaries, or Visual Multiple Stars with Good Parallaxes

Nearby visual double or multiple stars do not only inform us about the kinematics and the chemical composition of the Solar neighbourhood, as do single stars, but also give information about stellar masses near the Sun. If one of the components or both are slightly evolved, their age can also be estimated with the help of a grid of theoretical isochrones. After having determined the effective temperature and bolometric magnitude of each component we can draw a (log T_{eff}, M_{bol}) diagram representing a portion of the observational isochrone constructed with two, three, or more components of the visual system. The observational isochrone can then be compared with a grid of theoretical isochrones computed with the same metal abundance, Z, as the one previously found in analysing in detail the stars of the system, but with different He abundances, Y. In such a way, if we know the metal content of the observational isochrone (from the chemical analysis of its stars), the He content can be estimated from the theoretical isochrone which best fits the observational isochrone (Perrin et al. 1977). This procedure permits to estimate the He content of G and K stars too cold to show He lines in their spectra. If a computation of the orbit of a multiple system exists, the masses of the components are known. These masses can be compared with those determined by internal structure computations. This is a way to check if the physical input of the internal structure computations is correct.

We have already applied this procedure to near visual binaries or multiple systems (Cayrel et al. 1988, Cayrel de Strobel et al. 1989, Chmielewski et al. 1991, Chmielewski et al. 1992, Friel et

Table 2: *Basic parameters for some nearby Thin and Thick Disk stars*

HD	V	B-V	Sp	π_{trig}	U	V	W	log g	[Fe/H]	M_{bol}	T_{eff}	Obs
The triple system: 36 Ophiuci												
155886 A	5.05	0.86j	K0V	0.188 ± 0.008	+8	−19	+1	4.60 ± 0.20	−0.29 ± 0.06	6.23 ± 0.12	5125 ± 30	ESO
155885 B	5.08	0.86j	K1V	0.188 ± 0.008	+9	−19	+1	4.6 ± 0.20	−0.31 ± 0.05	6.25 ± 0.13	5100 ± 50	ESO
156026 C	6.34	1.16	K5V	0.183 ± 0.007	+8	−19	+1	4.70 ± 0.30	−0.36 ± 0.12	7.12 ± 0.12	4550 ± 75	ESO
The triple system: HD 53705. HD 53706. HD 53680												
53705 A	5.56	0.64	G2V	0.057 ± 0.006	−46	−59	−14	4.30 ± 0.20	−0.25 ± 0.05	4.60 ± 0.10	5870 ± 40	ESO
53706 B	6.79	0.80	K0V	0.057 ± 0.006	−47	−63	−15	4.50 ± 0.20	−0.28 ± 0.06	5.83 ± 0.10	5290 ± 60	ESO
53680 C	8.64	1.18	K5V	0.057 ± 0.006	−48	−61	−14	–	–	6.75 ± 0.15	–	–
The UMa stream – visual binary: γ Lep												
38393 A	3.60	0.47	F6V	0.127 ± 0.005	+26	+17	−3	4.3 ± 0.25	−0.14 ± 0.04	4.05 ± 0.12	6200 ± 40	CFHT
38392 B	6.15	0.94	K2V	0.127 ± 0.005	+26	+18	−4	4.5 ± 0.25	+0.02 ± 0.10	6.41 ± 0.12	4950 ± 70	CFHT
UMa stream dwarfs												
115043	6.85	0.60	G1V	0.049 ± 0.015	+24	+13	0	4.5 ± 0.25	−0.03 ± 0.06	5.22 ± 0.60	5830 ± 60	CFHT
72905	5.64	0.62	G0V	0.073 ± 0.006	+19	+13	−3	4.5 ± 0.25	−0.01 ± 0.06	4.90 ± 0.25	5850 ± 50	CFHT
41593	7.23	0.81	K0V	0.066 ± 0.010	+22	+12	−5	4.5 ± 0.25	+0.08 ± 0.08	6.18 ± 0.50	5350 ± 60	CFHT
The visual binary: 16 Cyg												
186408 A	5.96	0.64	G1.5V	0.047 ± 0.002	+26	−17	+8	4.28 ± 0.20	+0.06 ± 0.04	4.27 ± 0.06	5785 ± 40	OHP
186427 B	6.23	0.66	G2.5V	0.047 ± 0.002	+26	−19	+6	4.40 ± 0.20	+0.04 ± 0.04	4.53 ± 0.06	5770 ± 40	OHP
The visual binary: 39 Eridani												
26846 A	4.87	1.17	K3III	0.013 ± 0.010	+43	−31	−20	2.70 ± 0.30	+0.21 ± 0.06	+0.09 ± 1.20	4600 ± 40	CFHT
26846 B	8.57		G2V	0.013 ± 0.010	+43	−31	−20	4.10 ± 0.20	+0.19 ± 0.03	4.07 ± 1.20	5830 ± 50	CFHT
The α Centauri system												
128620 A	−0.01	0.68	G2V	0.743 ± 0.007	−20	+13	+21	4.31 ± 0.20	+0.22 ± 0.02	4.27 ± 0.02	5800 ± 25	ESO
128621 B	+1.33	0.895	K1V	0.743 ± 0.007	−20	+13	+21	4.58 ± 0.20	+0.26 ± 0.04	5.54 ± 0.03	5325 ± 50	ESO
Very nearby G and K dwarfs												
156384 A	6.10	1.04	K3V	0.140 ± 0.006	+13	+30	−29	4.50 ± 0.20	−0.59 ± 0.07	6.59 ± 0.12	4930 ± 50	ESO
100623	5.27	0.83	K0V	0.103 ± 0.008	−39	+32	+17	4.60 ± 0.20	−0.38 ± 0.06	6.00 ± 0.20	5232 ± 45	ESO
156274 A	5.53	0.80	G8V	0.133 ± 0.007	+38	+31	−20	4.50 ± 0.20	−0.35 ± 0.06	4.91 ± 0.12	5295 ± 45	ESO
4628	5.76	0.88	K2V	0.137 ± 0.004	+ 9	−33	− 3	4.60 ± 0.20	−0.29 ± 0.07	6.20 ± 0.08	4940 ± 50	ESO
115617	4.74	0.71	G6V	0.113 ± 0.007	−14	−35	−24	4.5 ± 0.20	−0.02 ± 0.07	4.93 ± 0.10	5585 ± 40	ESO
20630	4.85	0.68	G5V	0.109 ± 0.002	−14	+ 8	+ 2	4.50 ± 0.20	+0.04 ± 0.06	5.10 ± 0.07	5630 ± 40	CFHT
76151	6.00	0.67	G3V	0.056 ± 0.002	−22	− 6	+ 1	4.5 ± 0.20	+0.06 ± 0.03	4.65 ± 0.08	5710 ± 40	ESO
76151	6.00	0.67	G3V	0.056 ± 0.002	−22	− 6	+ 1	4.5 ± 0.20	+0.07 ± 0.05	4.65 ± 0.08	5710 ± 40	CFHT
17925	6.04	0.85	K2V	0.127 ± 0.006	− 6	− 4	− 4	4.6 ± 0.20	+0.10 ± 0.05	6.36 ± 0.13	5090 ± 35	ESO
125072	6.66	1.03	K3V	0.106 ± 0.007	−24	0	−22	4.5 ± 0.20	+0.26 ± 0.08	6.55 ± 0.20	4965 ± 50	ESO
Grb 1830	6.45	0.75	G9VI	0.103 ± 0.006	+280	−141	− 8	4.5 ± 0.10	−1.30 ± 0.06	6.34 ± 0.20	5170 ± 60	Mc Donald
Some proposed Solar analogues												
Sun	−26.74		G2V	–	+ 9	+12	+ 7	4.44	0.00	4.75	5770	–
44594	6.60	0.66	G3V	0.041 ± 0.014	+38	+51	+ 2	4.50 ± 0.20	+0.17 ± 0.05	4.59 ± 1.0	5770 ± 40	ESO
44594	6.60	0.66	G3V	0.041 ± 0.014	+38	+51	+ 2	4.50 ± 0.20	+0.13 ± 0.06	4.59 ± 1.0	5770 ± 40	CFHT
186427 B 16 Cyg B	6.23	0.66	G2.5V	0.047 ± 0.001	+26	−19	+ 6	4.40 ± 0.20	+0.04 ± 0.04	4.53 ± 0.06	5770 ± 40	OHP
28099 Hyades cluster	8.12	0.66	G2V	0.023 ± 0.004	−32	− 7	+ 5	4.50 ± 0.20	+0.14 ± 0.04	4.80 ± 0.08	5770 ± 40	CFHT
1835	6.39	0.66	G2V	0.044 ± 0.006	−27	− 3	+ 9	4.50 ± 0.20	+0.17 ± 0.04	+4.77 ± 0.07	5770 ± 40	CFHT

al. 1992). The results are given in Table 2. Although these results concern only 6 multiple visual systems (among them the UMa stream binary, γLep, and three stars of the UMa stream), the abundance range found for the six systems is as large as that of the Thin Disk population given in Table 1. Among the three oldest visual systems of the sample, HD 53705, 53706, and 53680, 16 Cyg A and B, α Cen A and B, the first in the list is metal deficient by a factor of 2, the second is metal normal, and the third is metal rich by a factor of 2.

We have also found that there is no abundance correlation between the "turn-off age" of the visual systems and their metallicity, in the sense that old stars can be metal rich, as is the case of αCenA and αCenB. Concerning kinematic results of the stars in Table 2, we see that the space velocity vectors U, V, W, of the stars of the 36 Oph system are very different from those of the HD 53705 system, in spite of their identical metallicities.

High Resolution, High S/N Survey of F, G and K Stars within 10 Parsecs of the Sun

The "Catalogue of Nearby Stars" of Gliese (1969) contains 69 non-degenerate stars with effective temperatures higher than 4000 K, and which are nearer than 10 parsecs from the Sun. Four of these stars are A stars, five are F stars and the remaining 60 are G and K dwarfs and slightly evolved subgiants. A few years ago, we decided to obtain for these stars a homogeneous set of well determined physical parameters: chemical composition, effective temperature, spectroscopic gravity, microturbulence, and if possible, age and mass. We hope that these results on the physical parameters of the nearest F, G, and K stars will be ready at the same time as their revised parallaxes resulting from the Hipparcos observations. Then, we shall have at our disposal reliable results which will allow to better understand the state of evolution and the chemical composition of our nearest stellar neighbours. We are currently taking at ESO and OHP observatories high resolution, high S/N spectrograms of those stars in the sample of 69 for which only poor spectroscopic data, or no data at all, are available (Perrin et al. 1988).

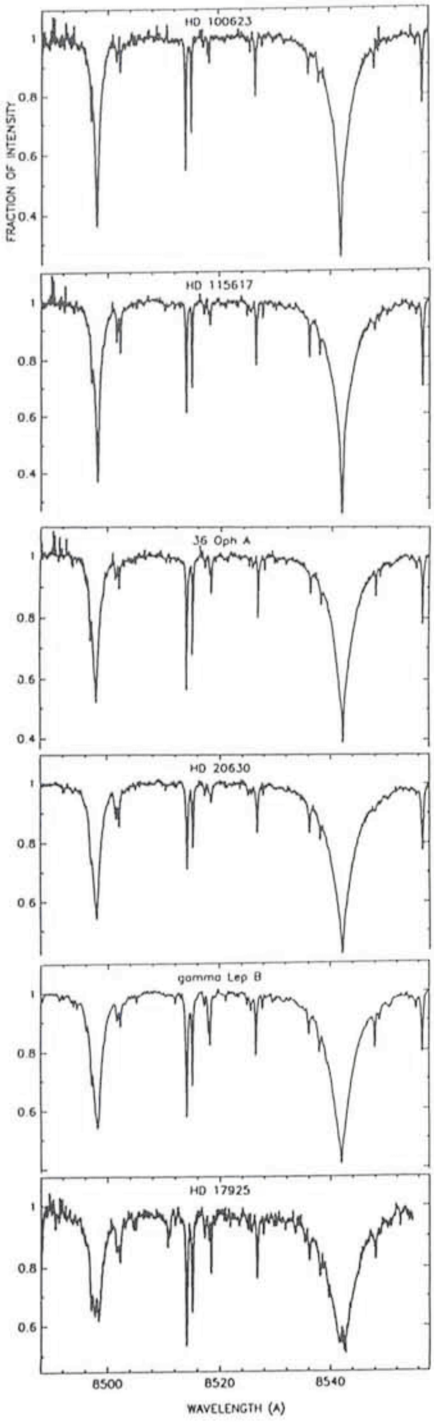

Figure 1: *Observed profiles of two of the Ca II infrared triplet lines (λ 8498.06 Å and λ 8542.14 Å) of six early K dwarfs, listed in Table 2, having about the same effective temperature. The central depths of these lines are excellent chromospheric activity indicators: the more shallow the lines are in the spectrum of a star, the more active is the chromosphere of this star. Please note the difference between the profiles of HD 100623 and HD 17925.*

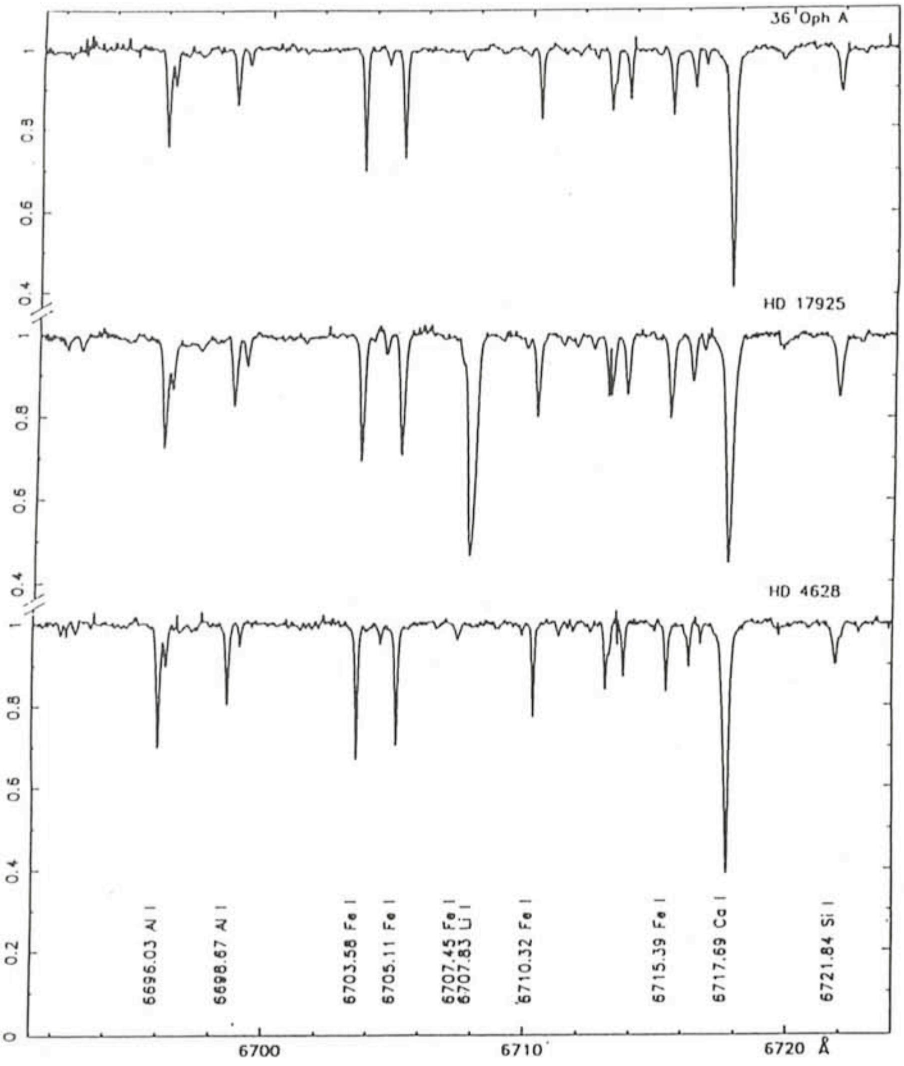

Figure 2: *ESO CAT-CES spectrum of HD 1792 K2V of the Li region as compared to the same region of two early K dwarfs: 36 Oph A K0V (upper spectrum) and HD 4628 K2V (lower spectrum). Please note the very strong Li line in HD 17925. No lithium is visible in 36 Oph A and in HD 4628. The feature just to the blue of the Li line is primarily due to Fe I (λ = 6707.4 Å).*

If we consider the [Fe/H] values, relative to the 16 stars nearer than 10 parsecs from the Sun, contained in Table 2, we find that the range of their metallicities is surprisingly large, from −0.59 dex to +0.26 dex, in this randomly selected, small sample of stars. This probably means that the nearest solar neighbourhood is populated with stars belonging to the Thick and the Thin Galactic Disk populations. By the way, there exists also one Halo star, Groombridge 1830, nearer than 10 parsecs from the Sun and hotter than 4000 K. We thought that it would be interesting for the reader to give in Table 2 for this star the same parameters as those given for the Disk stars. The stellar atmosphere parameters for Grb 1830 were taken from Smith et al. (1992).

The values of the space velocity components U (in the direction to the galactic centre) V (in the direction of galactic rotation), W (in the direction of the north galactic pole) are given in columns 6, 7, 8, of Table 2. The U, V, W of the 16

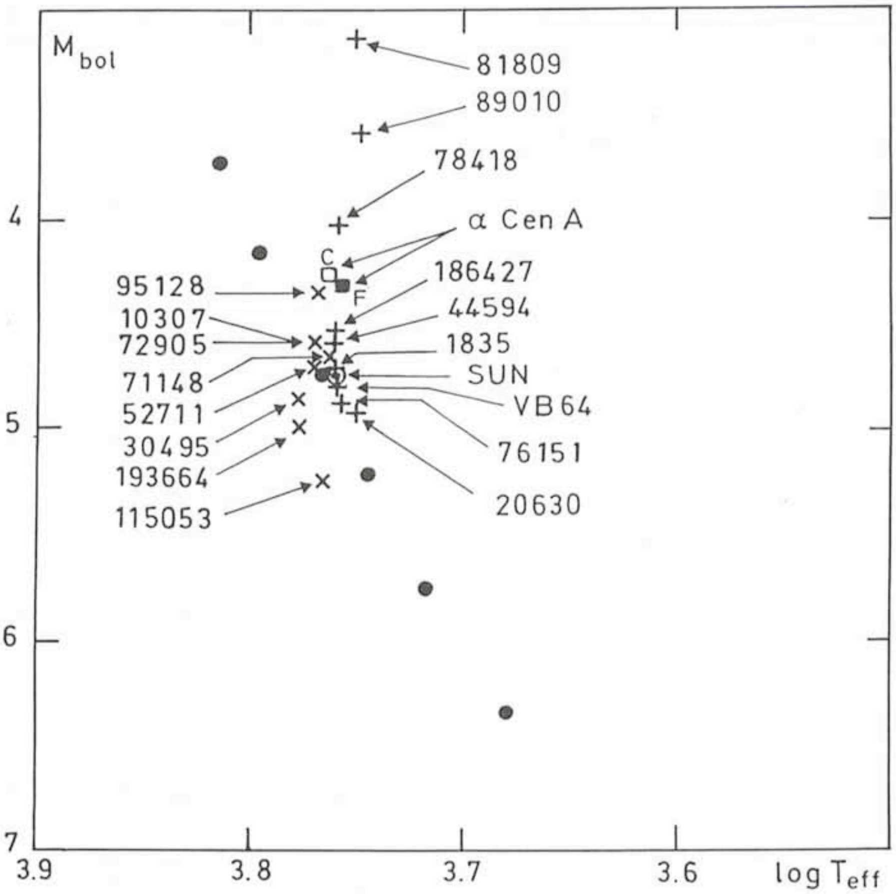

Figure 3: *Positions occupied in the (log T_{eff}, M_{bol}) diagram by solar analogues contained in Tables 3 and 4 of Cayrel de Strobel (1990). Plusses are stars from Table 3, and crosses stars from Table 4. Black circles are evolutionary models computed by Lebreton (Cayrel de Strobel et al. 1989) representing a theoretical ZAMS, ($Z=0.02$, $Y=0.287$, $\alpha=2.18$).*

nearest Disk stars exemplify the kinematic variety found in the solar neighbourhood.

A parameter which shows that the nearest solar neighbourhood is built up by young and old Disk stars is the strength of their chromospheric activity. Such activity is tightly connected to the age of a star. The central depths of the CaII doublet lines at λ3933.6 and 3968.5 Å and those of the CaII triplet lines at λ 8498.0, 8542.1 and 8662.1 Å are excellent indicators of chromospheric activity: the more shallow these lines are in the spectrum of a star, the more active is its chromosphere and the younger is the star. We have used the first two of the infrared lines of the CaII triplet (we could not observe the three lines together in a same spectral interval using high spectral resolution) for ranking the age of the observed Disk stars. In Figure 1 are represented the infrared profiles of these lines for six of our programme stars. In this figure we see that the central depth of the Ca II lines is deep for the first two stars, and becomes more shallow for the last stars. This shows the great difference in age between the first star, which is several billion years old, and the last star, only a few million years old.

Are there Very Young Stars in the Solar Neighbourhood? Yes, an Example: HD 17925

Nearly 98% of the stars in the solar neighbourhood belong to the Thin Disk Population (Nissen and Schuster 1991). Most of the field stars we have analysed and presented in Table 1 belong to the "old" Thin Disk population, having ages between solar and twice solar, approximately, whereas the UMa and the Hyades cluster stars belong to the "young" Thin Disk population, with ages between 0.2 and 0.7 Gy.

During one of our recent observing runs at ESO, we found in the spectrum of a nearby (7.9 parsecs) K2V dwarf a very strong lithium line (Cayrel de Strobel and Cayrel 1989). The presence of such a strong Li line in this low-mass star ($M = 0.8\ M_{\odot}$, $T_{eff} = 5090$) indicates that HD 17925 must be very young. Figure 2 reproduces ESO CAT-CES spectra of the Li region of HD 17925 as compared to the same region of two early K dwarfs. No lithium is visible in 36 Oph A (K0V) and in HD 4628 (K2V). Even in the comparatively young Hyades dwarfs, Li is already totally depleted in dwarf members with effective temperatures around 5200 K. The small age of HD 17925 is consistent with its high chromospheric activity, as shown in Figure 1 by the shallow central depths of its Ca II triplet lines. Observations with still higher spectral resolution are planned to study the structures of the cores of these lines.

Where does such a young star come from? We have investigated what could be the place of origin of HD 17925 using Contopoulos and Strömgren (1965) projected orbits of stars. We think that the star comes from the Scorpio-Centaurus complex, where it was formed a few million years ago

Photometric Solar Analogues Versus High-Resolution Spectroscopic Solar Analogues

This research (Cayrel de Strobel et al. 1981, Cayrel de Strobel and Bentolila 1989, Friel et al. 1992) has primarily been concerned with the question of whether photometric solar analogues remain such when submitted to detailed spectroscopic analysis. In other words, whether the physical parameters, like chemical composition, effective temperature, gravity, chromospheric activity, etc. as derived from a detailed spectroscopic analysis of a photometric solar analogue, will be identical, or at least very similar to those of the Sun? For example, the photometric solar analogue, the Hyades dwarf VB 64, while having the same T_{eff} as the Sun (Cayrel et al. 1985), is certainly not a real solar twin, because the age (0.7 Gy versus 4.5 Gy) and chromospheric activity of the Sun and VB 64 are very different. Also the chemical composition is different $[Fe/H]^{64}_{\odot} = +0.15 \pm 0.03$ dex, and so is their state of evolution, the Sun being slightly more evolved than the much younger Hyades star.

Photometric solar analogues have been proposed by different authors, and the lists can be found in Cayrel de Strobel (1990; Table 3 and 4). Figure 3 shows the position of the Sun and of some photometric solar analogues in a theoretical (log T_{eff}, M_{bol}) diagram. Detailed spectroscopic analyses of the stars in Figure 3 have shown that none of them is a real solar twin.

The two stars which most ressemble the Sun, are 16CygB in the northern hemisphere, and the photometric analogue, HD44594, discovered by Hardorp (1978), in the southern hemisphere. The Ca II infrared profiles of these two stars together with those of the Sun and the Hyades dwarf, VB 64, are reproduced in Figure 4. The central depths of the Ca II profiles of the first three stars are very similar, indicating that the three of them have very low chromospheric activity. The central depths of the Ca II profiles of VB 64 are smaller than those of the first stars indicating a substantial difference in chromospheric activity, hence in age, between VB 64 and the other three stars.

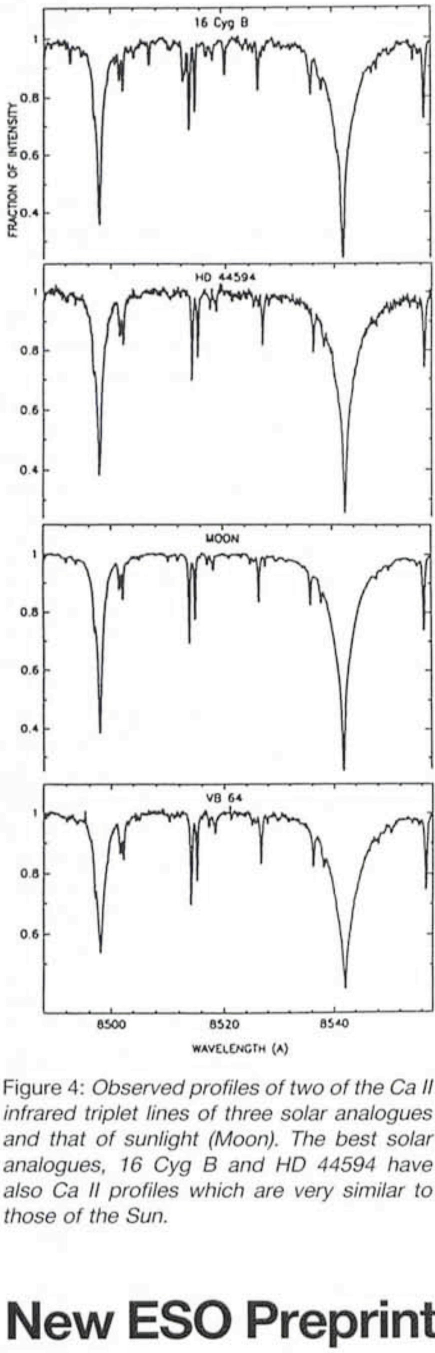

Figure 4: *Observed profiles of two of the Ca II infrared triplet lines of three solar analogues and that of sunlight (Moon). The best solar analogues, 16 Cyg B and HD 44594 have also Ca II profiles which are very similar to those of the Sun.*

SMR Disk Stars Versus SMR Bulge Stars

New spectroscopic CCD and Reticon observations have confirmed the existence of nearby G and K stars with metallicities higher than those of the Hyades, the so-called SMR (super metal rich) stars. A good example of them are the stars in the binary system α Cen A and B, our nearest neighbours (see in Table 2 the values of their [Fe/H]).

A few years ago, we determined with the help of the [Fe/H] Catalogue (Cayrel de Strobel 1992), the "turn-off age" of a sample of slightly evolved SMR subgiants. We found a great spread of age between the oldest and the youngest SMR stars. We constructed for these SMR subgiants an age versus [Fe/H] relation, and found that the slope of the relation was slightly negative for younger ages of SMR stars. This could be an indication that the SMR phenomenon was more active in the past than it is now, but has always existed in the Thin Disk Population. The discovery by Withford and Rich (1983) of a group of very metal rich stars in the Bulge of our Galaxy with metal abundances more than 3 times that of the Sun, may support the existence of a very metal rich population of stars in the Galactic Bulge (Rich 1990a, Rich 1990b).

Conclusion

In this article, after having briefly introduced the concept of galactic subsystems or stellar populations, we have discussed Disk stars, belonging to the solar neighbourhood. The physical parameters: chemical composition, effective temperature spectroscopic gravity, microturbulence, have been determined in a very homogeneous way and are based on excellent observational material, of which more than half comes from ESO observations. The results show that the solar neighbourhood is populated with a great variety of objects. We hope that by combining space observations with ground-based observations and improving our methods of reduction and interpretation, the physical status of some of the above-discussed stars will be known in a detail that is comparable to that available for the Sun.

References

Cayrel de Strobel, G., Knowles, N., Hernandez, G., Bentolila, C.: 1981 *A&A* **94**, 1.
Cayrel, R., Cayrel de Strobel, G., Campbell, B.: 1985 *A&A* **146**, 249.
Cayrel, R., Cayrel de Strobel, G., Campbell, B.: 1988, in IAU Symp. 132, p. 449.
Cayrel de Strobel, G., Bentolila, C.: 1989, **211**, 324.
Cayrel de Strobel, G., Cayrel, R.: 1989, *A&A* **218**, L9.
Cayrel de Strobel, G., Perrin, M.N., Cayrel, R, Lebreton, Y.: 1989, *A&A* **225**, 369.
Cayrel de Strobel, G.: in XIth European Regional IAU Astronomy Meeting, Cambridge University Press, Eds. F. Sanches and M. Vazquez, p. 195.
Cayrel de Strobel, G., Hauck, B., François, P., Thévenin, F., Friel, Mermilliod, M., Borde, S., 1992, *A&AS* **95**, 273.
Chmielewski, Y., Cayrel de Strobel, G., Lebreton, Y., Bentolila: 1991, *A&A* **247**, 386.
Chmielewski, Y., Friel, E., Cayrel de Strobel, G., Bentolila, C.: 1992, *A&A* **263**, 219.
Contopoulos, G., Strömgren, B.: 1965, Tables of Plane Galactic Orbits, Goddard Space Flight Center, NASA.
Friel, E., Cayrel de Strobel, G., Chmielewski, Y., Spite, M., Lebre, E., Bentolila, C.: 1992, in preparation for *A&A*.
Gilmore, G., Reid, N.: 1983 *MNRAS* **207**, 223.
Gilmore, G., Wyse, R. F.: 1985 *AJ* **90**, 201.
Gliese, W.: 1969, *Catalogue of nearby stars*, Veröff. Astron. Rechen-Inst. Heidelberg, No. 22.
Hardorp, J.: 1978, *A&A* **63**, 383.
Laird, J. B, Rupen, M. P., Carney, B. W., Latham, D. W.: 1989, in: "The abundance spread within globular clusters" IAU Joint Comm. Meeting No. 5. Eds: G. Cayrel de Strobel, M. Spite, T. Lloyd Evans; Pub. by Obs. de Paris p. 37.
Nissen P. E., Schuster, W. J.: 1991, *A&A* **251**, 457.
Perrin M. N., Hejlesen, P. M., Cayrel de Strobel, G., Cayrel, R.: 1977, *A&A* **54**, 779.
Perrin, M. N., Cayrel de Strobel, G., Denefeld, M.: 1988, *A&A* **191**, 237.
Smith, G., Lambert, D. L., Ruck, M. J.: 1992, *A&A* **263**, 249.
Rich, R. M.: 1990a First ESO/CTIO Conference: Galactic Bulges, Eds. B. J. Jarvis, D. M. Terndrup, La Serena, Chili p. 65.
Rich, R. M.: 1990b, *Ap. J.* **362**, 604.

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(September–November 1992)

Scientific Preprints

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and its Jet. *Monthly Notices of the Royal Astronomical Society.*

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     Proc. Conf. "Astronomy from Large Databases II", Sept. 14–16, 1992, Haguenau, France.
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881. F. Bertola et al.: The External Origin of the Gas in S0 Galaxies. *Astrophysical Journal,* Letters.
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884. R.A.E. Fosbury: Evidence for Anisotropy and Unification. Invited paper presented at the 33rd Herstmonceux Conference "The Nature of Compact Objects in AGB". Cambridge, July 16–22, 1992.
885. R. Siebenmorgen: The Spectral Energy Distribution of Star Forming Regions. *The Astrophysical Journal.*
886. L. Greggio et al.: Star Formation in Dwarf Irregular Galaxies: DDO 210 and NGC 3109. *The Astronomical Journal.*

Technical Preprint

49. R.N. Wilson et al.: Active Correction of Wind-Buffeting Deformations of Thin Telescope Primaries in the Extended Active Optics Bandpass. Submitted to *Journal of Modern Optics.*

A Study of T Tauri Stars and Li-Rich Giant Star Candidates

B. BARBUY, J. GREGORIO-HETEM, B. V. CASTILHO, University of São Paulo, Brazil

We have recently started a programme to analyse low veiling T Tauri stars. Earlier work was done on the basis of data obtained in 1986 by U. Finkenzeller (Finkenzeller and Basri, 1987) at the 3.6-m ESO telescope, while we computed synthetic spectra of molecular bands (Batalha, Gregorio-Hetem and Barbuy, 1992).

We are now studying T Tauri stars listed in the paper by Gregorio-Hetem et al. (1992) who used the IRAS Point Source Catalogue to select candidates to be T Tauri stars by means of special colour criteria. These candidates were systematically observed in the Laboratório Nacional de Astrofísica (LNA), Brazil, in the Hα + Li wavelength region. We also used the 1024×640 ESO # 9 CCD and the short camera at the 1.4-m CAT telescope to observe a few T Tauri stars in various wavelength ranges. In particular, we observed Henize 1, a high galactic latitude T Tauri star, located far from any star-formation site; one of the interests of the LNA survey is to look for isolated groups of T Tauri stars, like the TW Hya group (de la Reza et al., 1989).

In these studies, we intend to compute molecular bands and contribution functions to better understand the atmospheric structure of these stars, to better define stellar parameters and to understand, for example, the reasons for their high Li-abundances (in some cases higher than in the ISM).

Another interesting object we observed is CPD −55° 395, located close to Hen 1, a Li-rich metal-poor giant. In order to learn whether this star, which shows a strong Li line and Hα and [OI] lines in absorption, might be a post T Tauri star or a Li-rich giant, we observed it in several wavelength ranges and carried out a detailed analysis. We have obtained its parameters, $[Fe/H] \approx -1.0$ and ^{12}C:$^{13}C \approx 10$, i.e. typical of an asymptotic giant branch (AGB) star. It shows a Li abundance of $\log \varepsilon(Li) \approx 1.3$. If its AGB nature is confirmed, then this Li abundance must be considered very high. H. Lindgren measured the radial velocity with Coravel and found $V^r = 71$ km s^{-1}, at the lower limit of what can be considered a halo star.

In order to better understand Li-rich giants, we have plotted the IRAS colours of the Li-rich giants given in the literature: the result is that they are indeed confined in a small range of colours. Further studies may indicate the possible cause of the Li enrichment in these stars, and the evolutionary stage where this occurs. This might allow us to understand the Li-enrichment in our Galaxy. We recall that a controversy exists concerning the identification of the cosmological lithium abundance and the population I or population II stars measurements. If the population II value of log N(Li) ≈ 2 (Spite and Spite, 1982) represents the cosmological value, a model is necessary to explain the values of log N(Li) ≈ 3 found in disk population I stars (Boesgaard and Steigman, 1985), which means an enrichment of a factor 10 between the two populations. These Li-rich giants are perhaps the Li enriching agent in the Galaxy.

References

Batalha, C., Gregorio-Hetem, J., Barbuy, B.: 1992, in preparation.
Boesgaard, A. M., Steigman, G.: 1985, *ARA & A* **23**, 319.
Finkenzeller, U., Basri, G.: 1987, *ApJ* **318**, 823.
Gregorio-Hetem, J., Lepine, J.R.D., Quast, G.R., Torres, C.A.O, de la Reza, R.: 1992, *AJ* **103**, 549.
de la Reza, R., Torres, C.A.O., Quast, G., Castilho, B.V., Vieira, G.L.: 1989, *ApJ* **343**, L61.
Spite, F., Spite, M.: 1982, *A&A* **115**, 357.

IR Stellar Photometry in Globular Clusters Using IRAC2

M.D. GUARNIERI[1,2], A. MONETI[3], V. TESTA[4], L. ORIGLIA[5,2], F.R. FERRARO[6], F. FUSI PECCI[6]

[1]Istituto di Fisica Generale, Università di Torino, Italy; [2]Osservatorio Astronomico, Torino, Italy; [3]European Southern Observatory, La Silla, Chile; [4]Dipartimento di Astronomia, Università di Bologna, Italy; [5]Dipartimento di Astronomia, Università di Firenze, Italy; [6]Osservatorio Astronomico, Bologna, Italy

1. Introduction

Globular clusters represent the *oldest, simple* population in galaxies. Hence, the study of their properties yields crucial information on the early evolutionary phases of the parent galaxy. Moreover, they are the best *laboratory* to study stellar evolution and one of the most powerful tools to grasp basic cosmological problems, like for instance the definition of the distance and time scales.

In fact, on the one hand, the detailed comparison between stellar evolutionary tracks and observed colour-magnitude (c-m) and colour-colour (c-c) diagrams allows us to check the reliability of the theoretical models (which actually are the engine of the *stellar clock*) and, on the other, the correct measure of the turn-off luminosity of the main sequence in individual clusters which is the crucial item to determine precisely their ages and, thus, to put significant constraints to the age of the Universe.

The availability of infrared (IR) magnitudes may be extremely useful in this task, particularly if combined with optical data. For instance, the V-K colour is an excellent indicator of effective temperature (T_{eff}), being relatively insensitive to metallicity and having a long wavelength baseline. Besides, extinction is much lower in the IR than in the optical bands. Finally, in the IR the contrast between stars to measure and the unresolved background is different and in particular, for stars populating the giant branch, is greater than in any optical region.

Though the significant advantages of observing individual globular cluster stars in the near IR are well known for many years (see for references Frogel et al., 1983), the technical limits intrinsic to the available detectors (single-channel aperture photometers) have unfortunately restricted in the past the observations to a few bright stars in the external regions of a small sample of clusters (Frogel et al. 1983, Arribas *et al.* 1991 and references therein).

The recent introduction of the IR arrays has opened new perspectives. In particular, the availability of new cameras, based on 256 × 256 arrays having pixel sizes and performances close to those of optical CCD's, will surely exploit soon the great potential impact of IR observations of large samples of globular cluster stars.

We present here the main outlines of our global project and the first results of a photometric survey of Galactic globular clusters started with IRAC2, the new

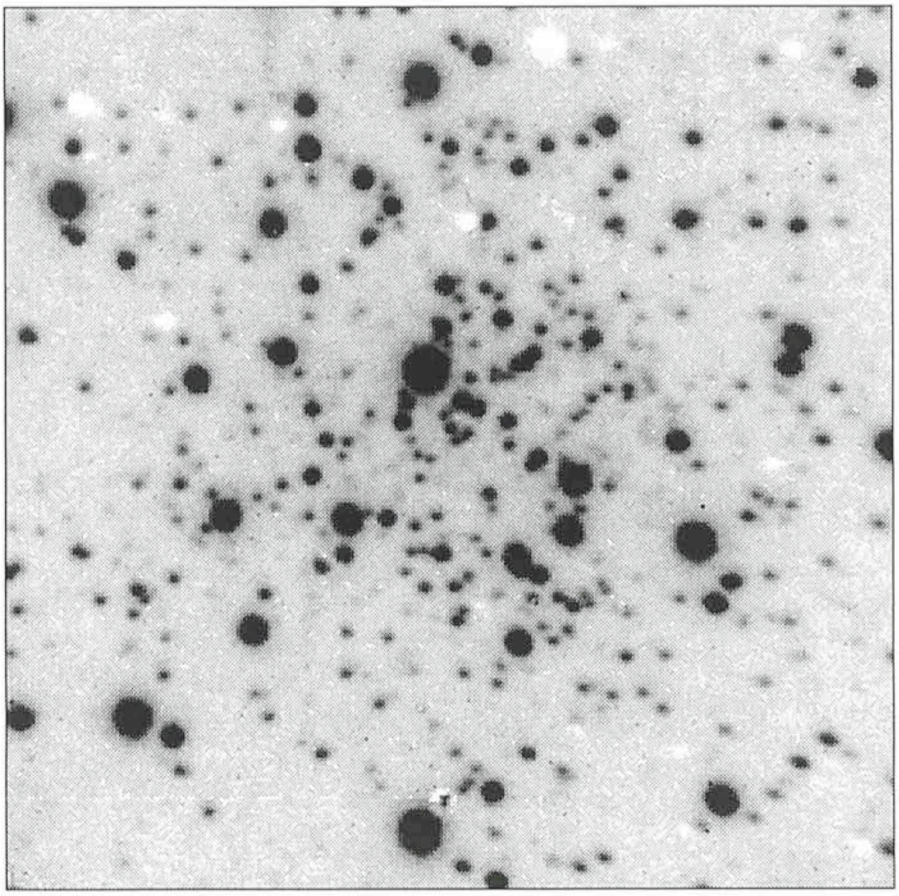
Figure 1: *M69 Central Region as observed with IRAC2, 0.27"/px mode, field size ~70×70".*

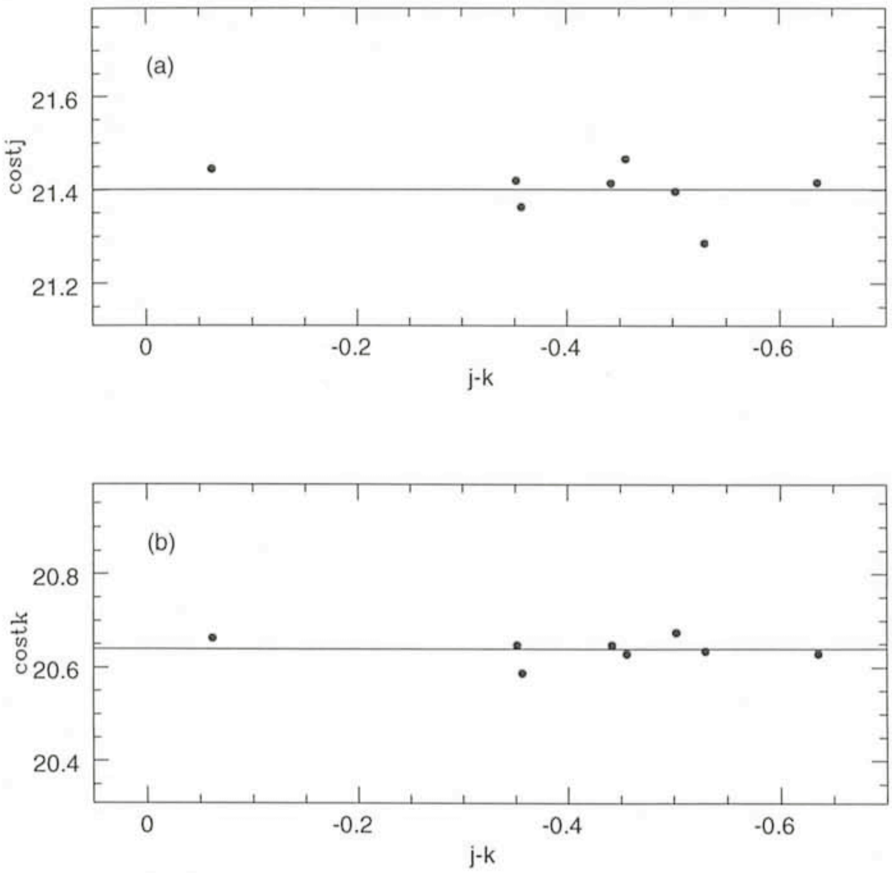

Figure 2 a, b: *Provisional calibration curves.*

highly performing IR camera developed at ESO. In particular, we show the preliminary results obtained for the low-latitude, metal rich-cluster M69 = NGC 6637. Since JHK data obtained using a Rockwell 256 × 256 NICMOS3 array at the 3.6-m CFHT have already been reported for this cluster by Davidge and Simons (1991), we decided to observe it first and reduce immediately the data for making useful comparisons and to improve at best our observing and reduction procedures.

A complete presentation of the observational strategy and data reduction techniques will be given in a forthcoming paper (Guarnieri et al., 1993) together with a preliminary discussion of the results.

2. Main Outlines of the Project and Observational Strategy

From the IR survey of the brightest stars in about 30 Galactic globular clusters, Frogel et al. (1983) got the first quantitative, detailed description of their upper giant branches with varying metal content. In summary, they showed that the absolute locations of the globular cluster giant branches correlate with metallicity, the observed luminosities of the brightest giants are in agreement with the theoretical model predictions, and, finally, that the integrated light measurements of the cluster as a whole correlate with the cluster parameters determined from measurements of its brightest individual members in a way that can be understood within the current knowledge of stellar evolution. Based on these facts, the same group has also systematically used integrated near-IR data for a sample of globular clusters in the Milky Way, in the Magellanic Clouds, and in M31 to investigate their stellar content and to compare them with elliptical galaxies.

Though very important, the data-base used by Frogel and co-workers includes however only about 350 stars in total. Therefore, due to the small number of stars observed in each cluster, the significance of some results is somewhat reduced, and problems like the precise estimate of the giant tip luminosity and the determination of an accurate mean ridge line down to the turnoff could hardly be faced.

Hence, the first obvious use of the new IR imagers is to secure observations of much wider samples of stars in many clusters with varying cluster metallicity, galactocentric location, age, etc. Moreover, it has been shown (Longmore et al., 1990; Buckley and Longmore, 1992) that it will now be possible to obtain fairly accurate and very deep IR photometry (2–3 mag below the turnoff, at K ~ 20) in the closest clusters. Thus, a completely new window can be opened on the problem of the determination of cluster distances and ages. In this respect, it is also important to recall that the conversion of two sets of the most frequently used isochrones in the IR planes carried out by Bell (1992) will permit a direct, stringent comparison between the observed and theoretical quantities.

Within this new exciting scenario, and exploiting the exceptional capabilities offered by IRAC2, we have started a long-term project intended to secure near IR photometry (JHK) of very wide samples of stars in many Galactic globular clusters down to the main sequence with the specific aim of touching upon the following items:

● *(i) The actual extent in luminosity and the location in temperature of the giant branch.* This can give a quantitative determination of the luminosity of the stars at the *helium flash* with varying metallicity, and set strong constraints on mass loss and on the masses of currently forming White Dwarfs. Moreover, one could also check the reliability of the location of theoretical models in the observational plane and eventually their scaling with metallicity, getting for instance direct tests of the dependence of the mixing length parameter α and colour-temperature transformations on metallicity. Incidentally, one will also get a consistency check of the various metallicity scales, and an indirect estimate of the actual influence of the horizontal branch morphology on the metallicity derived from integrated cluster observations (see Zinn and West, 1984).

● *(ii) The calibration of a new, very accurate method for the determination of the cluster distance scale.* Once the small number effects disappear, thanks to the complete observations of the giant branch stars in the cluster cores, the luminosities of the brightest objects are *bona fide* indicators of the actual giant branch tip whose absolute luminosity is expected to be constant for fixed chemical composition (see the Sweigart and Gross [1978] models). Hence, very accurate relative distance moduli (to better than ±0.1mag) can be obtained by simply imposing the coincidence of the RGB tips in clusters having similar abundances (Crocker and Rood, 1984). For instance, this will probably yield the solution of the long-standing problem of the *second parameter* (clusters with similar metallicity but very different HB morphologies). Moreover, the use of the various c-c diagrams will illuminate the origin of the discrepancy, if any. It will also be possible to use the so-called "IR flux method" (Blackwell and Shallis, 1977, Blackwell et al.,

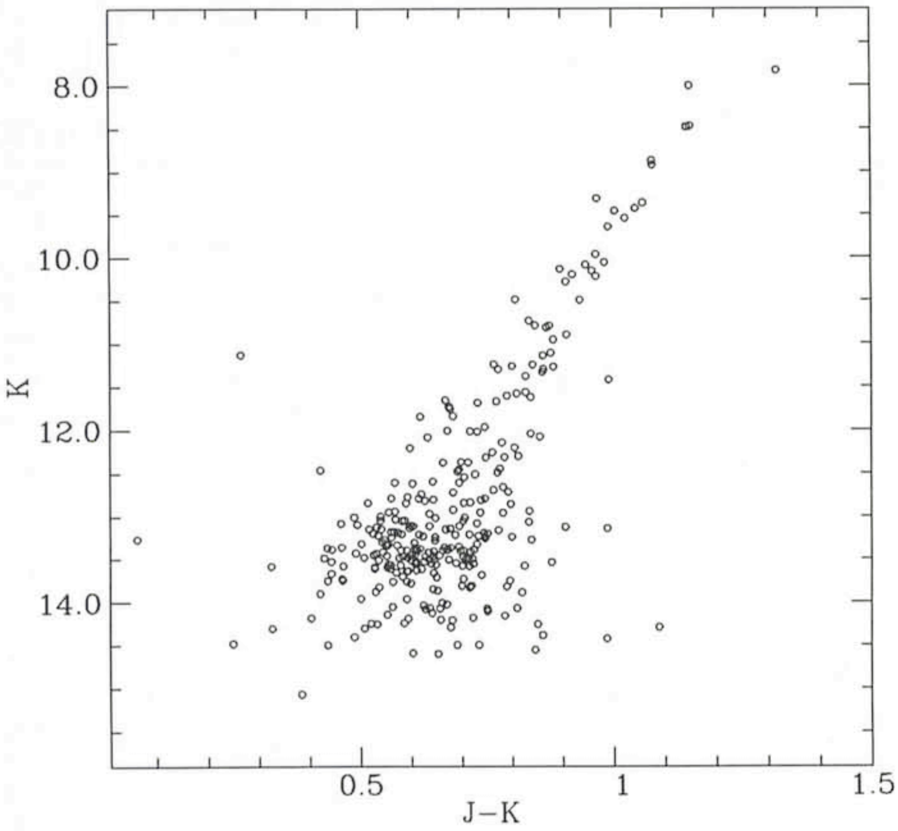

Figure 3: *M69 Colour-Magnitude diagram of the high-resolution central region.*

1980 and Arribas and Martinez Roger, 1987) to get an independent estimate of the distance for comparison.

● *(iii) The study of the turnoff region and the age.* It is well known that the luminosity and the temperature of the main-sequence turnoff in the c-m diagram are very sensitive to the absolute age, but they depend also on the chemical composition and mixing length. It is also known that a major uncertainty in the age determination is related to the knowledge of the distance (Renzini, 1991), often further complicated by an insufficiently accurate measure of the interstellar reddening. Taking into account the results achieved from point (ii) above and, as discussed in detail by Longmore et al. (1990), Bell (1992), Buckley and Longmore, (1992), by combining optical and IR magnitudes of equivalent photometric accuracy it will be feasible to constrain significantly the possible range of the various parameters involved (for instance via the comparison and compatibility tests of the various c-m and c-c diagrams). The long-standing problem that the most frequently used isochrones computed by VandenBerg and Bell (1985) transformed into the observational plane seem to show a systematic shift of 0.02–0.03 mag blueward in B-V (VandenBerg, 1986) could be eventually solved. In particular, it is not clear whether the shift could be due to poor transformations between the two planes or to the models themselves. The availability of the IR colours will clarify this issue or other similar ones because V-K is an excellent indicator of effective temperature and the various c-c diagrams will give hints on the cause of the shift, if any.

● *(iv) The study of the contribution of the various evolutionary stages to the cluster integrated light in each photometric band and bolometrically.* A proper examination of this item requires the use of very populous and *complete* samples which can only be achieved by mapping with the new large arrays vast areas of the cluster, including the central regions. This represents a big observational and reductional effort, but it is very important in view of the use of globular clusters as templates in the stellar population synthesis techniques. In particular, the IR observations are essential when observing very metal-rich clusters. These clusters are projected onto the Galactic bulge and are unique homogeneous samples of bulge population. Their optical c-m diagrams are dominated by blanketing effects giving origin to a turnover on the giant branches (Ortolani et al., 1990). At present there are no models that correctly fit these features in spite of recent efforts to produce new isochrones for solar abundance low-mass stars. The major difficulty seems to be the transformation from the theoretical to the obser-

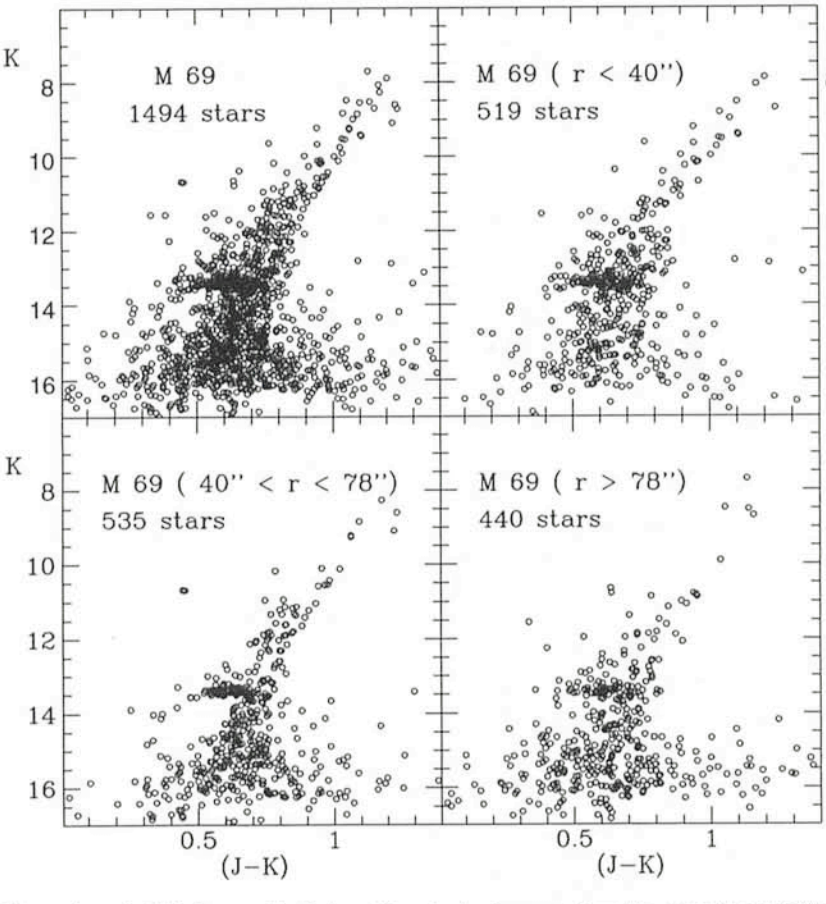

Figure 4a–d: *M69 Composite Colour-Magnitude diagrams from the mosaicked fields.*

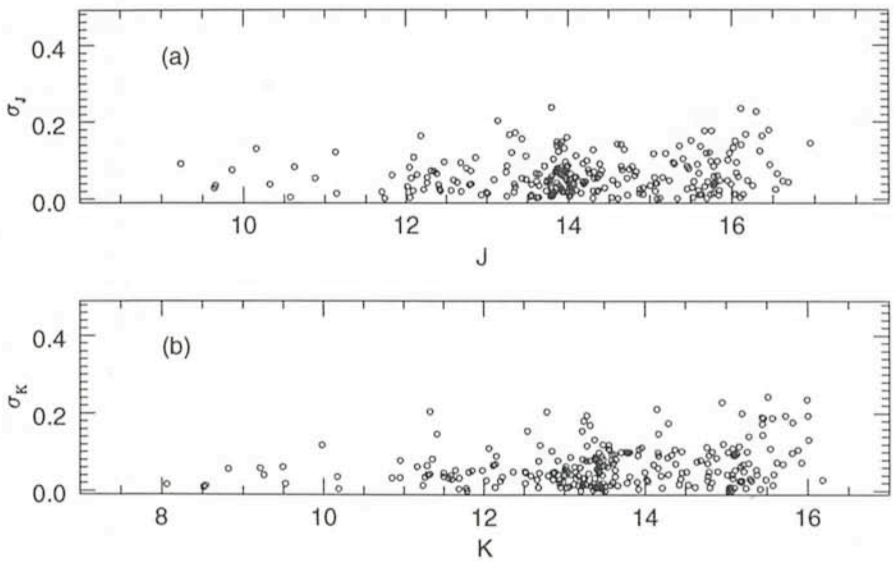

Figure 5a, b: *Internal errors overall behaviour.*

vational plane due to the heavy blanketing effect. It is clear that only bolometric luminosities and effective temperature determinations via combined optical-IR measurements can improve the current theoretical research in this field.

Concerning the observational strategy, as said, the IR arrays provide the best way to get unbiased samples of stars over a wide range of magnitude. In particular, IRAC2 is optimal to study the Galactic globular clusters offering the facility to vary the pixel scale. Therefore, for each cluster we have planned to take a mosaic exposure made by one field centred on the cluster observed with high spatial resolution (0.27″/px) plus four fields with a common vertex in the cluster centre, partially overlapping one each other and with the central field. Moreover, to reach the faintest possible magnitude limit in the K-band, we have selected one of the four fields off centre and planned to secure further specific exposures. Finally, for each cluster a few other fields will be observed to survey the stars already observed by Frogel and collaborators for comparison.

In summary, the brightest stars in most of the clusters we have planned to observe have magnitudes V ~ 11–12 and colours *V–K* ~ 2–4; the faintest objects are about 9 magnitudes fainter. Hence, assuming that about 20–50 stars populate the upper 1.5-mag region of the giant branch in each cluster (this number has been computed taking into account the integrated luminosity of the clusters and the giant branch evolutionary phases, see Renzini and Fusi Pecci, 1988), we can get sufficiently populous samples and guarantee good statistics. On the other hand, thanks to the possibility of varying the scale of the camera, this procedure guarantees also a sufficient spatial resolution and photometric sampling to deal with the central crowded regions. Moreover, the availability of overlapping areas will allow us to carry out various tests about the photometric accuracy and the degree of completeness actually achieved in the reductions.

3. Observations and Data Reduction

The observations of M69 described here were made on June 10, 1992 with the newly commissioned "IRAC2" mounted on the ESO/MPI 2.2-m telescope. For a detailed description of IRAC2 see Moorwood et al. (1992). The following observations were performed: (i) high resolution (0.27″/pixel) J and K images of the cluster centre; (ii) 4 fields centred on the corners of a ~ 100″ × 100″ square in J and K at medium resolution (0.49″/pixel). Integration times were 60 co-adds × 1 sec for both (i) and (ii). Separate sky frames were obtained with the same integration times ~ 10′ away from the cluster centre. Figure 1 shows a plot of the central frame obtained in the K-band.

Faint photometric standard stars (from SAAO, kindly provided by Dr. Ian Glass) were observed for calibration, and flat fields were obtained on the fading or brightening sky at sunset and at sunrise. For each filter/lens combination, several images were obtained with a fixed integration time, and an image with little signal was subtracted from an image with high signal in order to subtract possible signal arising from the instrument and/or the telescope and to be left with an image of *pure flat field* (see also Moorwood et al., 1992). All observations were carried out close to the zenith and with photometric sky; the average seeing was slightly less than 1″.

Source images were reduced by subtracting the corresponding sky and with it the fixed pattern (or bias) and dark current. When several sky frames were available, these were combined via a stack median filter to remove field stars. These difference images were then divided by a normalized flat field.

Photometry was carried out using ROMAFOT (Buonanno et al., 1979, 1983), a crowded field photometry package. ROMAFOT fits a Moffat function to the stellar profile in order to determine its volume and hence the instrumental magnitude

$$M_{\mathrm{inst.}} = -2.5 \times \log(\mathrm{Volume})$$

That is:

$$M_{\mathrm{inst.}} = -2.5 \times \log(\mathrm{Volume}) = -2.5 \times \log[(\pi h^2 \sigma)/(\beta - 1)]$$

where

h = height of the stellar component

σ and β = Moffat function parameters.

The zero point of the calibrations was obtained by making aperture photometry on an uncrowded sample of bright stars located in the outer regions of the fields and matched to 8 SAAO standards observed in the same nights with the same set-up. They have been repeatedly observed during the same night, yielding a r.m.s scatter always less than 0.02 mag. In particular, two of them have been observed also in the other 3 nights. The *internal* scatter of the various measures is very low. For the star HD 202964 we got $\sigma_K = 0.008$ and $\sigma_J = 0.014$ mag, while for HD 194107 we had 0.032 and 0.011 mag, respectively.

Concerning the calibration of the central high-resolution field, since no safe bright uncrowded stars were available, we have used the stars in common with the overlapping low-resolution regions to transfer the calibration.

The complete description of the calibration will be given in the full paper in preparation. Figure 2 presents the calibration curves used to determine the photometric zero-point here provisionally adopted.

4. The Preliminary IR Colour-Magnitude Diagrams

The IR c-m diagram we present in Figure 3 includes the stars identified in the central field and observed with the best pixel-scale (0.27″/px). By inspecting the plot, we see immediately that the giant branch is highly populated and well defined. In fact, even observing the very central crowded regions of the

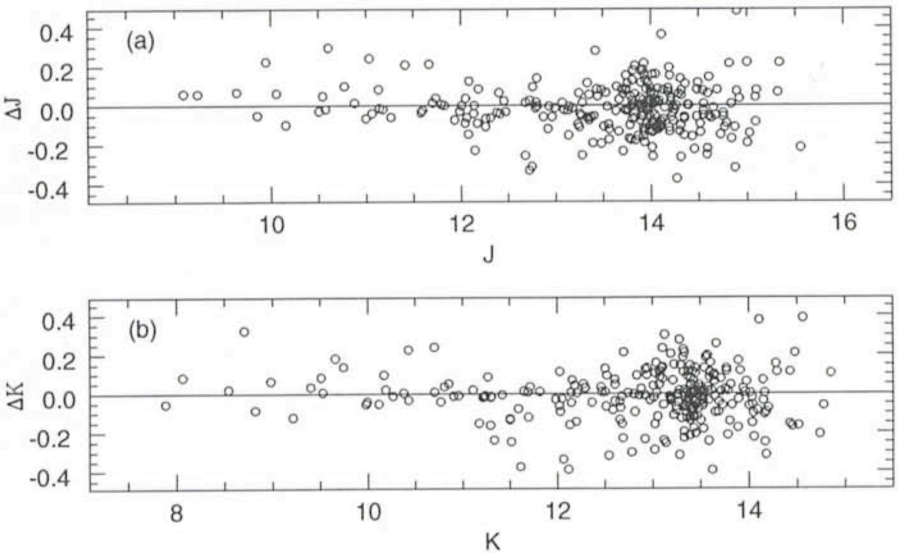

Figure 6a, b: *Plot of the residuals in magnitude for the stars measured on both high-resolution central region and low-resolution mosaicked fields.*

cluster, it is now possible to determine a reliable mean ridge line up to the giant branch tip. Note that also the Horizontal Branch (HB) has clearly been reached in this central quite short exposures, and a mean locus could already be drawn using only these data.

In Figure 4a–d, we present the IR c-m diagrams obtained from the reduction of the four mosaicked fields observed with the larger pixel-scale, including also the central region overlapping the high-resolution central survey. As said, these exposures are deeper and, hence, a deeper K-limit has been reached, almost close to the expected turnoff region.

In particular, in Figure 4a we present the c-m diagram for all the 1497 measured stars (no completeness tests have been carried out yet), while c-m diagrams for radial bins are shown in Figure 4b,c,d.

These IR c-m diagrams seem to be suitable to carry out the kind of analysis we aimed at. In particular, the Red Giant Branch (RGB) is well traced up to the tip, and it can also be possible to locate the Asymptotic Giant Branch (AGB) as a quite scattered distribution of stars above the HB and bluer than the RGB. Note that in these plots the HB is tightly defined and narrow, yielding a very precise average luminosity, K = 13.4 ± 0.05. It is very red and stubby, as expected for metal rich globular clusters. The Subgiant Branch (SGB) is wide due to the increasing photometric scatter and to the possible presence of field objects which can also be found at brighter magnitude levels, located outside the main branches (but their photometry will be specifically checked). To confirm the high statistical significance achievable with this new IR c-m diagrams, it may also be noted that a hint for the presence of the expected RGB-bump (see Fusi Pecci et al., 1990) can already be found in the present preliminary study at K ~ 13.55.

A complete analysis and discussion of these data will be the subject of the forth-coming paper (Guarnieri *et al.*, 1993).

5. Photometric Errors and Comparison with Previous IR Data

The preliminary analysis we performed here shows quite convincingly that, by using IRAC2, it will be possible to carry out a wide and very accurate new IR survey in the Galactic globular clusters, measuring very wide samples of post-Main Sequence stars up to the cluster centre (at least for the clusters with low and intermediate concentration). Moreover, taking advantage of the possibility of varying the pixel-scale, it will also be possible to study the radial behaviour of the photometric errors and of the degree of completeness. This item is crucial for getting statistically significant luminosity functions for comparisons with the theoretical models.

For sake of example, we report here two plots to show the variation of the estimated internal photometric errors with varying magnitude and pixel size. Then, we present a comparison of our magnitudes with those listed by Davidge and Simons (1991) for a subset of stars in common.

Figure 5 presents the distributions of the *internal* errors in the photometry of the stars located in the overlapping areas of the mosaicked fields, computed using the formula given in Ferraro et al. (1991) and plotted versus the final J and K magnitudes obtained for each star. No specific segregation has been made among crowded and uncrowded images. As can be seen, most of the stars display errors less than 0.1 mag even at quite faint magnitudes, and even on the crowded objects the internal errors are smaller than 0.2 mag.

The results of another interesting test carried out using the available data are shown in Figure 6. There, we report the plots of the residuals of the magnitudes obtained in the same band for the stars in common in the overlapping central regions observed with the two different pixel-scales. From the plot, the existence of a scatter becomes evident which tends to increase up to 0.3–0.4 magnitudes at the faint limits. The size of these residuals is quite high and it would require a further, more detailed analysis. However, a quick preliminary inspection has already revealed that the distribution of the residuals is essentially driven by the relative depth of the used exposures (the high-resolution ones are less deep) and by three basic groups of stars, i.e. (1) the sufficiently bright and uncrowded objects, which yield very small residuals; (2) the very crowded objects, which usually lead to high values for the residuals independent of the brightness; (3) the faint objects, whose residuals may be large or small depending on their location with respect to brighter nearby companions. This overall trend clearly indicates that the use of a higher spatial resolution in the central regions may be crucial to manage the crowded objects as, besides the incidence on the degree of completeness (still to test however), it may affect the obtained magnitudes for the most crowded objects up to a few tenths of a magnitude.

Finally, to have an independent check of the reliability of the magnitudes and colours obtained from these preliminary reductions, we have compared our results with those presented by Davidge and Simons (1991) for the stars in common. To carry out this preliminary comparison we have not aimed at getting a complete overlay (which is currently in progress), but we have simply identified a first subset of stars produced by making a rough coincidence of their published coordinates transformed to our internal reference system. This implies that we cannot yet say anything about the relative degree of completeness, nor on the actual ability to resolve blended images. However, the results of the preliminary comparisons shown in Figure 7 a–c are already very encouraging. The agreement between the two sets of measurements is excellent for the bright stars both in J and in K, and it is still good down to the HB level. Taking into account the fact that the data presented by Davidge and Simons (1991) reach a magnitude limit brighter than the measures here presented, the above comparisons seem to indicate that for the stars in common displaying a sufficient S/N in both photometries, the computed magnitudes agree very well. Moreover, although we have not examined the issue in detail, it seems also that the agreement is quite independent of the crowding. Since both observations were carried out with similar scales (0.27 and 0.29″/px here and DS, respectively), it may also suggest that crowding problems have been similarly dealt with in the two studies.

The colour comparison (see Fig. 7c) is slightly less good. There is some indication for the existence of a weak systematic trend which has to be further studied. It has certainly to be ascribed to the different observational set-up and standard stars used, and further measurements of many more standards are necessary to determine a reliable colour transformation from one system to the other.

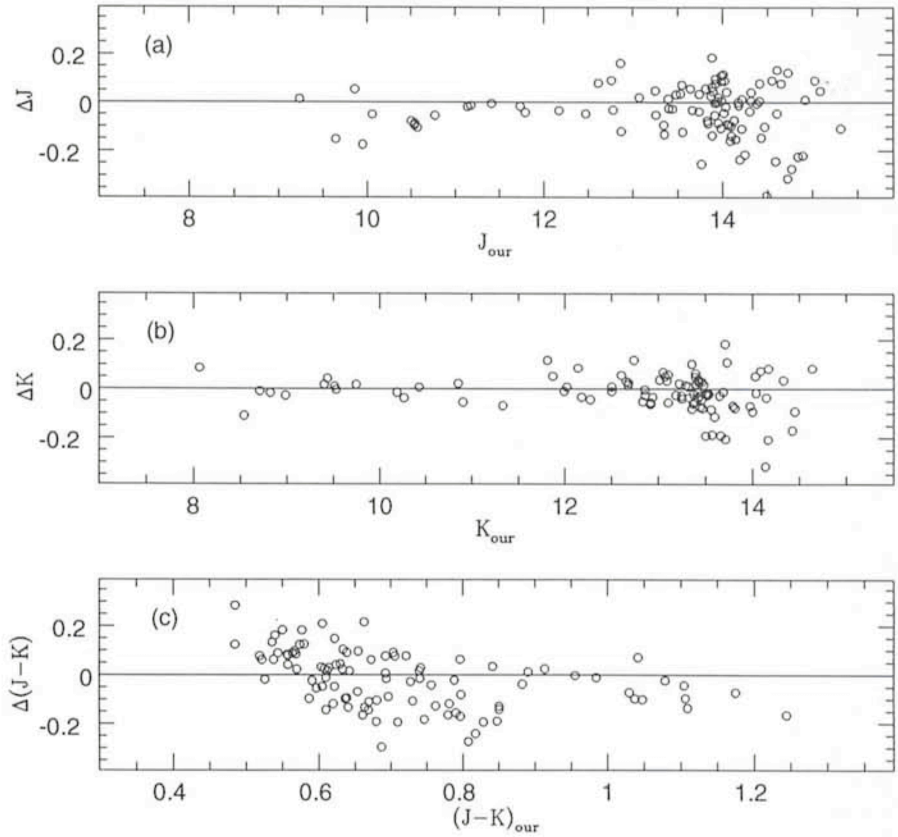

Figure 7a–c: *Plot of the residuals (Davidge and Simons – Ours) versus our values for the subset of common stars.*

6. Preliminary Conclusions and Future Prospects

The present preliminary study has confirmed that the new infrared camera IRAC2 now available for use at ESO is perfectly suitable to satisfy all the basic requirements put forward by a very accurate and deep IR photometry of wide samples of individual stars, even in the central regions of most of the Galactic globular clusters.

After securing a proper set of frames and using a reduction package purposely aimed at dealing with crowded fields (like ROMAFOT or DAOPHOT), we believe it is now possible to obtain the description of the whole c-m diagram of the cluster in the IR and also in the combined IR-optical planes down to a few magnitudes below the turnoff with a remarkable internal accuracy (~ 0.1 mag) at K ~ 20.

A variety of problems related to a *quantitative* check of the stellar evolutionary models and to a significant improvement in the cluster distance and age determinations can now be successfully addressed.

Acknowledgements

We would like to thank the ESO organization for the allocation of observing time and for giving us the chance to be the first IRAC2 users. We also thank Hans Gemperlein for the help during the observing run.

References

Arribas, S. and Martinez Roger C. 1987 *Astron. Astrophys.* **178**,106.

Arribas, S., Caputo, F. and Martinez Roger C. 1991 *Astron. Astrophys. Suppl. Ser.*, **88**, 19.

Bell, R.A. 1992, *Mon. Not. R. Astr. Soc.* **257**, 423.

Blackwell, D.E. and Shallis, M.J. 1977, *Mon. Not. R. Astr. Soc.* **180**, 177.

Blackwell, D.E., Pedford, A.D. and Shallis, M.J. 1980. *Astron. Astrophys.*, **82**, 249.

Buckley, D.R.V. and Longmore, A.J. 1992. *Mon. Not. R. Astr. Soc.*, **257**, 731.

Buonanno, R., Corsi, C.E., De Biase, G.A. and Ferraro, I. 1979. In *Image processing in Astronomy*, eds. G. Sedmak, M. Capaccioli and R. J. Allen, Trieste Obs., p. 354.

Buonanno, R., Buscema, G., Corsi, C.E., Ferraro, I. and Iannicola, G. 1983. *Astron. Astrophys.*, **126**, 278.

Crocker, D.A. and Rood. R.T. 1984. in *Observational Tests of the Stellar Evolution Theory*, eds. A. Maeder and A. Renzini, (Reidel: Dordrecht), p. 159.

Davidge, T.J. and Simons, D.A. 1991. *Astron. J.*, **101**,1720.

Ferraro, F.R., Clementini, G., Fusi Pecci, F. and Buonanno, R. 1991. *Mon. Not. R. Astr. Soc.*, **252**, 357.

Frogel, J.A., Cohen, J.G. and Persson, S.E. 1983. *Astrophys. J.*, **275**, 773.

Fusi Pecci, F., Ferraro, F.R., Crocker, D.A., Rood, R.T. and Buonanno, R. 1990. *Astron. Astrophys.* **238**, 95.

Guarnieri, M.D., *et. al.*, 1993. In preparation.

Longmore, A.J., Dixon, R.I. and Guarnieri, M.D. 1990, in *Astrophysics with Infrared Arrays*, ed. R. Elston, A.S.P. Conf. **14**, 121.

Moorwood A., *et. al.* 1992. *The Messenger*, **69**, 61.

Ortolani, S., Barbuy, B. and Bica, E. 1990. *Astron. Astrophys.*, **236**, 362.

Renzini, A., *1991*. In *Observational Tests of Cosmological Inflation*, NATO ASI Series C, Vol. 348, 131.

Renzini, A. and Fusi Pecci, F. 1988. *Ann. Rev. Astron. Astrophys.*, **26**, 199.

Sweigart, A.V. and Gross, P.G. 1978. *Astrophys. J. Suppl.*, **36**, 405.

VandenBerg, D.A. and Bell, R.A. 1985. *Astrophys. J. Suppl.*, **58**, 561.

VandenBerg, D.A. 1986. *Mem. S.A.It.*, **57**, 373.

Zinn, R.J. and West, M.J. 1984. *Astrophys. J. Suppl.*, **55**, 45.

ASTRONOMY FROM LARGE DATA BASES II

The Proceedings of this Workshop, held at Haguenau, France, from September 14 to 16, have just been delivered. The 534-page volume, edited by A. Heck and F. Murtagh, is available at a price of DM 70,– (prepayment required).
Payments have to be made to the ESO bank account 2102002 with Commerzbank München, or by cheque, addressed to the attention of ESO, Financial Services, Karl-Schwarzschild-Str. 2, Garching bei München, Germany.

Distances to Extragalactic RR Lyrae Stars Using IRAC2

J. STORM and A. MONETI, ESO La Silla

1. Introduction

Extragalactic distances based on Pop-II stars are of great importance to check the Cepheid distance scale and its zero point since Pop-II objects like RR Lyrae stars are not calibrated using the distance to the Pleiades but provide a truly independent approach.

Longmore et al. (1986) showed that there exists a well-defined Period-Luminosity relation for RR Lyrae stars when using the mean K magnitude as the luminosity indicator, and Longmore et. al. (1990) have made extensive investigations of RR Lyrae stars in Galactic globular clusters. The K band is an excellent band to use for distance estimates because it is fairly insensitive to metallicity and to uncertainties in the reddening, two problems which haunt most optical calibrators.

IRAC2 mounted on the 2.2-m ESO/MPI telescope has enabled us to observe stars down to about 19th magnitude in about an hour (half of the time is spent on sky measurements) making it feasible to observe RR Lyrae stars in the LMC. The big field (2′ × 2′) compared to previous cameras also enables us to cover a significant part of globular clusters in the LMC and thus to observe several RR Lyrae stars simultaneously. We describe here some test observations on the old LMC globular cluster NGC1841 (Walker 1990), in which we successfully measured 11 RR Lyrae stars in a single field, and we present some preliminary results.

2. Observations and Photometry

On September 9, 1992 we obtained six images of the cluster shifted randomly within a ≈ 25″ diameter region. The exact position was chosen with the help of a finding chart from Walker (1990) in such a way as to maximize the number of RR Lyrae stars in the field of view, and also making certain that we included stars covering a large range in period. Each image was actually an average of ninety 3-sec images, and was followed by a similar integration on a sky position about 200″ south of the cluster.

From each source image we subtracted the average of the bracketing sky frames and then rebinned the image by a factor of two before shifting and stacking the results to produce the image shown in Figure 1. The frames were stacked by taking the median of the six frames whereby the bad pixels were efficiently eliminated except for the bad rows at the lower left. The final image comprises the area in common to the six frames and the FWHM of the stars is a mediocre 1.4″.

Although we could not identify the RR Lyrae stars in the individual frames, DAOPHOT succeeded in finding 11 of the variables in the stacked frame. The DAOPHOT ALLSTAR programme furthermore succeeded in measuring stars down to 19.5 mag and the estimated uncertainty of an 18.5 mag star is about 0.2 mag.

The instrumental magnitudes were transformed to the standard system using a number of faint standard stars ($8 < K < 9.5$) and corrected for extinction assuming $E(B-V) = 0.18$, following Walker (1990), giving $A_K = 0.1 \times 3.1\ E(B-V) = 0.06$ mag. This low value of the absorption illustrates one of the important features of the infrared Period-Luminosity relation, namely the weak sensitivity to uncertainties in the reddening estimates.

3. Results

Walker (1990) determined the periods for these stars and using these periods together with the K magnitudes derived here, we can construct a $\langle K \rangle$-logP diagram (Fig. 2). Although we have not observed the mean K magnitude, $\langle K \rangle$, but just the K magnitude at a random phase for each star, the uncertainty introduced on each datum from this simple approach is less than 0.2 mag for each point because the amplitude in the K band is only about 0.3 mag peak-to-peak. From the typical shape of the K light curve for these stars, it is expected that most of the stars will be slightly brighter (≈ 0.1 mag) than the mean value and a few stars will be significantly fainter (≈ 0.2 mag). The large number of stars helps to average out this error and the resulting relation can be established reasonably well. We find a best fitting straight line of the form

$$\langle K \rangle = -2.3(\pm 0.5)\log P + 17.06(\pm 0.10). \qquad (1)$$

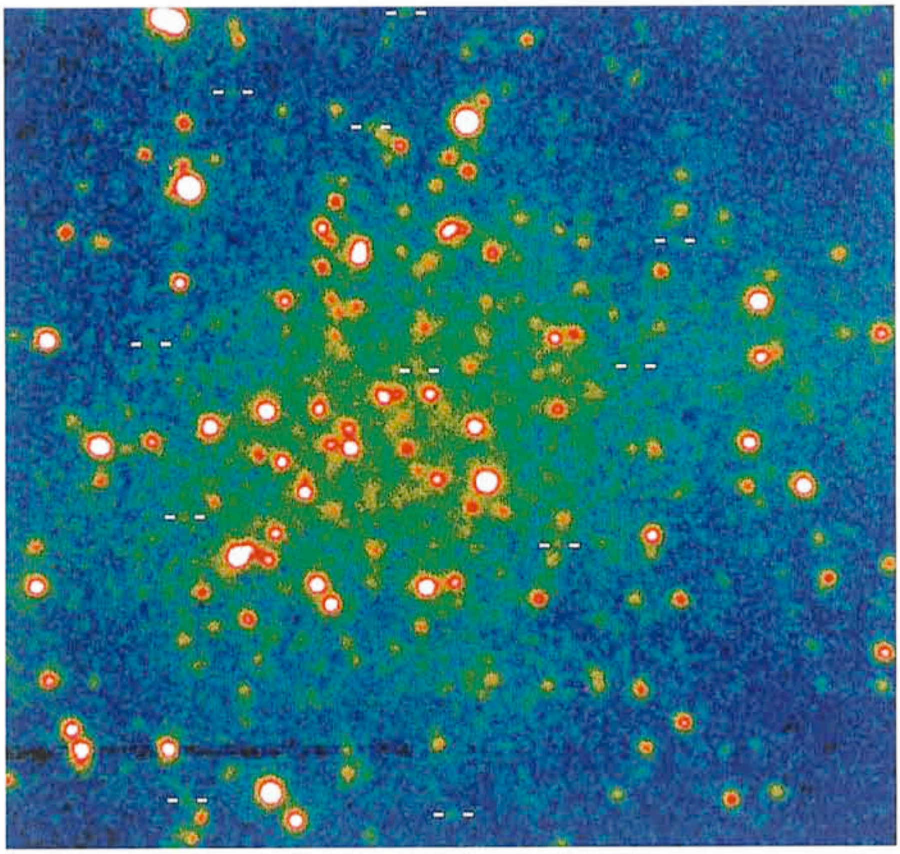

Figure 1: *K-band image of NGC1841 as seen by IRAC2 with the measured RR Lyrae stars marked. The image is made of a stack of 6 individual frames each of which is made up of ninety 3-sec integrations giving a total of 27 minutes of integration. The frame contains only the area covered by all six frames (≈110″×110″) and is thus slightly smaller than the field covered by a single exposure.*

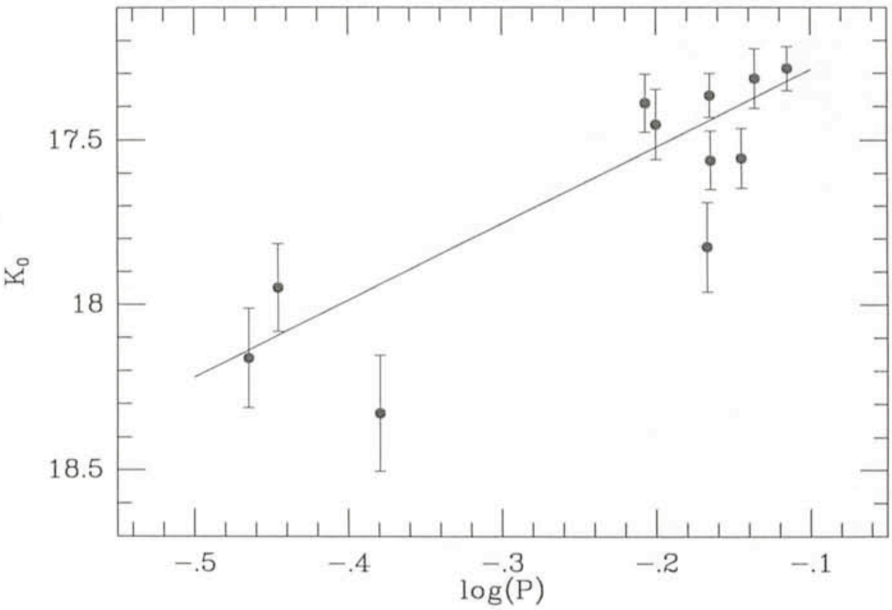

Figure 2: *The Infrared Period-Luminosity relation as derived from the RR Lyrae stars of NGC1841. The line is the best fitting line through the weighted data points.*

This result is in excellent agreement with the relation found for galactic RR Lyrae stars by Jones et al. (1992) using the Baade-Wesselink method, which is

$$\langle M_K\rangle = -2.33(\pm 0.20)\log P - 0.88(\pm 0.06). \qquad (2)$$

While it might be coincidental that the slopes agree so well, the result clearly indicates that the slope $d\langle K\rangle / d \log P$ determined for Galactic RR Lyrae stars can also be applied to low metallicity RR Lyrae stars in the LMC, and the relation can thus be used to determine the distance to such stars.

From the above equations we derive a distance modulus of 17.94 ± 0.15 to NGC1841, where the uncertaintly reflects internal errors only. This value is in excellent agreement with the results of Walker (1990) when adjusted to a common zero point. He derives a value of 18.19 from the $\langle M_V\rangle$−[Fe/H] relation assuming a value of +0.5 mag for $\langle M_V\rangle$ at [Fe/H] of −2.2 dex. Jones et al. (1992), on the other hand, find a value of +0.67 mag more appropriate based on the same Baade-Wesselink results that provides the basis for Eq. 2. Correcting the modulus of Walker (1990) accordingly, we derive a modulus of 18.02 mag.

To further constrain the slope, we are attempting to obtain more data at different phases to decrease the scatter due to the random phasing of the data points and to improve the S/N for the faintest of the stars. Finally, we intend to measure stars in more LMC clusters to increase the sample size.

For a discussion of the adopted zero points see e.g. Carney et al. (1992) and Cacciari et al. (1992).

NGC1841, being located almost 15 degrees from the bar, is known to be far from the centre of the LMC. Walker (1990) argues that NGC1841 is approximately 0.3 mag closer than the LMC centre and adding in this offset leads to a modulus of 18.24 to the centre of the LMC. This is about 0.3 mag closer than suggested by the most recent Cepheid calibration (see Feast 1991), but in good agreement with other LMC RR Lyrae data (e.g. Walker 1992). A similar difference between distances based on RR Lyrae's and Cepheid's found by Saha et al. (1992) in the Local Group galaxy IC1613, suggest that there is a problem either with the zero point of one or both of the methods or that there are still effects like differences in chemistry which are not taken properly into account in the various methods.

In conclusion we must stress the importance of the big efforts that are currently being put into the better understanding of the various distance calibrators as well as their zero points.

References

Cacciari, C., Clementini, G., Fernley, J. A.; *ApJ*, **396**, 219, 1992.

Carney, B. W., Storm, J., Jones, R. V.; *ApJ*, **386**, 663, 1992.

Feast M. W.; in *Observational Tests of Inflation*, Eds. T. Banday and T. Shanks, Kluwer, Dordrecht, p. 147, 1991.

Jones, R. V., Carney, B. W., Storm, J. and Latham, D. W.; *ApJ*, **386**, 646, 1992.

Longmore, A. J., Dixon, R., Skillen, I., Jameson, R. F. and Fernley, J. A.; *MNRAS*, **247**, 685, 1990.

Longmore, A. J., Fernley, J. A., and Jameson, R. F.; *MNRAS*, **220**, 279, 1986.

Saha, A., Freedman, W., Hoessel, J. G., Mossman, A. E.; *AJ*, **104**, 1072, 1992.

Walker, A. R.; *AJ*, **100**, 1532, 1990.

Walker, A. R.; *AJ*, **103**, 1166, 1992.

The Great Annihilator in the Central Region of the Galaxy

I.F. MIRABEL, Service d'Astrophysique, CE-Saclay, France

1. The Sepulchral Silence of the Hypothetical Super-Massive Black Hole

For two decades gamma-ray astronomers observing the galactic centre region with many balloon and satellite-borne instruments have been reporting intermittent radiation from the annihilation of positrons with electrons. Positrons are electrons of positive charge that annihilate when they meet ordinary matter, producing pairs of photons of 511 keV, the rest-mass energy of the annihilated particules.

The sporadic appearance of this type of gamma radiation in the central region of our Galaxy indicated the existence of a compact object (or objects) capable of fabricating enormous quantities of positrons in short periods of time. The poor angular resolution of the detectors used until recently gave wide latitude to the belief that the mysterious compact source of positrons could be a black hole of several million solar masses residing at the dynamic centre of the Galaxy.

However, the French gamma-ray telescope SIGMA on board the Russian satellite GRANAT has recently found[1] that the strongest source of 511 keV gammas is not at the dynamic centre of the Galaxy, but 50 arcminutes away from it (Fig. 1). On October 13–14, 1990, SIGMA detected from this source

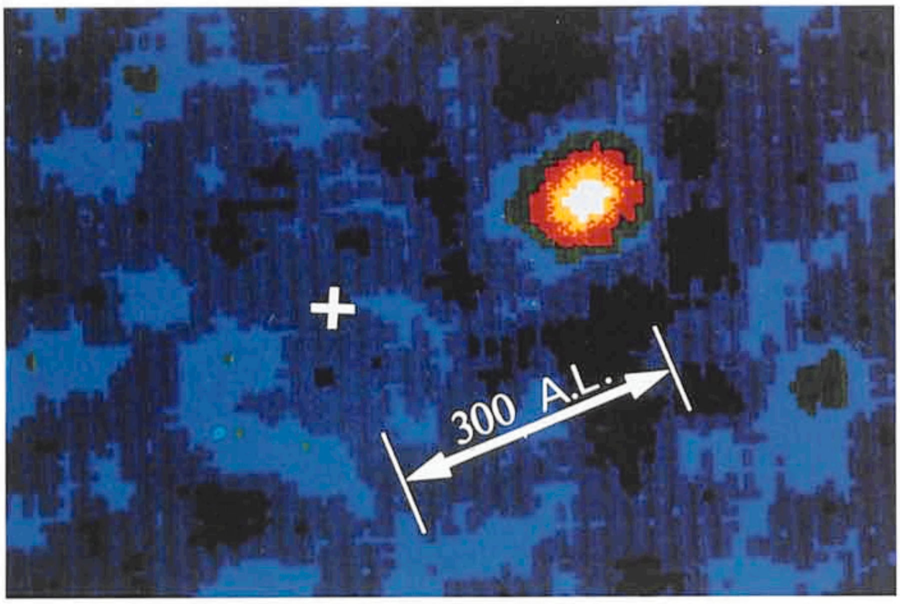

Figure 1: *Image of the Great Annihilator of positrons near the Galactic Centre obtained by the SIGMA telescope on board of GRANAT. Contrary to the expectations, in hard X-rays (40-120 keV) the strongest source is not at the dynamic centre of the Galaxy (white cross), but 50 arcminutes away from it (~ 300 light-years at the distance of the galactic centre). (Photo CEA/CESR/CNES.)*

a powerful annihilation burst[2], and we then realized that this object is the strongest compact annihilation source known in the Galaxy. Since it can fabricate 10 billion (10^{10}) tons of positrons in just one second, it is now known under the name of the "Great Annihilator".

The Great Annihilator may be a black hole of stellar mass. In its standard state, the X-ray spectrum resembles that of the stellar-mass black-hole candidate Cygnus X-1, both in shape and intrinsic luminosity. Furthermore, dynamic studies of sources detected by SIGMA beyond 100 keV show that they are likely to be binary systems with gravitationally collapsed objects having masses between 3 and a few tens of solar masses.

2. A "Microquasar" Ejecting Positrons Into the Cold Interstellar Medium

To know the nature of this extraordinary source we have carried out ground-based multiwavelength observations coordinated with the observations by SIGMA from space. Due to the high interstellar absorption along the line of sight to the central region of the Galaxy, the optical identification of a binary companion is very difficult[3]. Therefore, we have undertaken a programme of observations at centimetre, millimetre, and infrared wavelengths using the Very Large Array (VLA), the 30-m telescope of the IRAM, and the 2.2-m telescope of ESO.

Our search for a radio counterpart of the compact source of positrons had an unexpected turn[4]. Using the VLA we find inside the error circle of the X-ray and gamma-ray telescopes a compact radio source that varies in a synchronized way with the high energy source. This compact variable source is the radio counterpart of the Great Annihilator. A pair of radio jets whose centre coincides with the variable source was soon discovered[4] (see Fig. 2). These jets, at least three light-years long, are probably synchrotron emission from positron-electron pairs streaming out at high velocities from the source of antimatter.

The broad annihilation line detected by SIGMA from the Great Annihilator must be distinguished from the variable component of the narrow annihilation line observed since two decades from the galactic centre region. The broad line was observed only once, in less than one day. This implies that the annihilation took place in a region smaller than 200 astronomical units. If the observed redshift of 20 % is gravitational, the annihilation took place in a region closer than 10 Schwarzschild radii from the black hole (for a black hole of stellar mass, the Schwarzschild radius is a few tens of km). This annihilation medium must have a size smaller than a few hundred kilometres in radius, temperatures above 10^8 K, and should be essen-

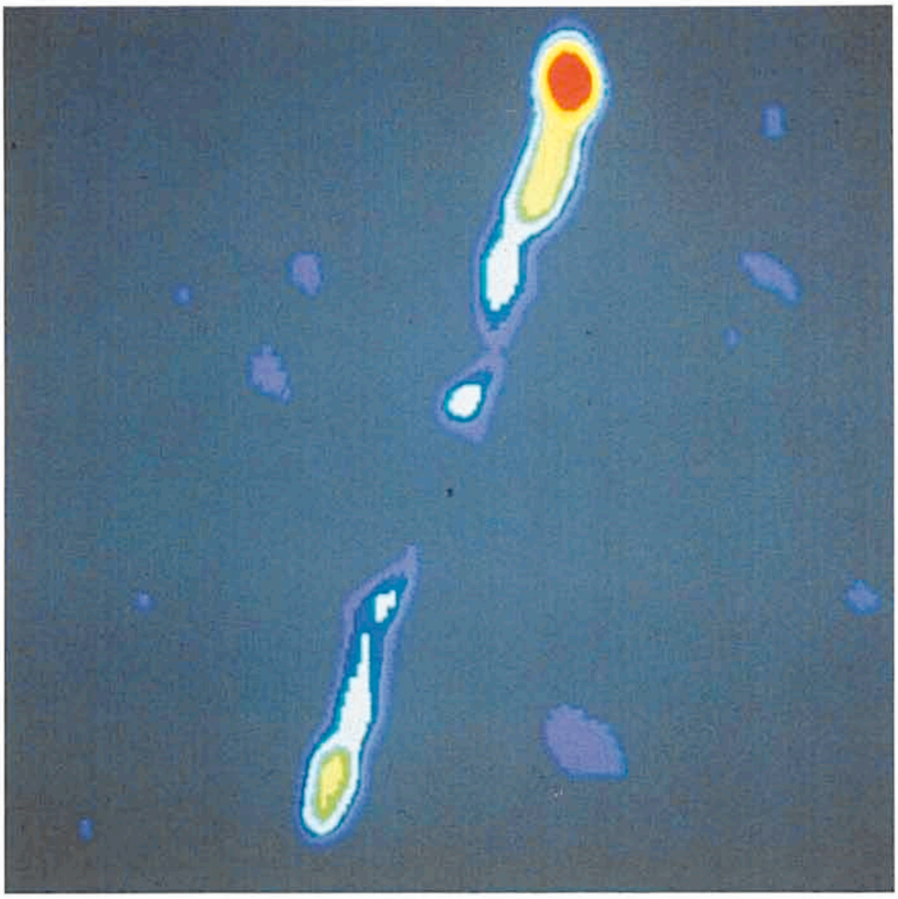

Figure 2: *This 20-centimetre VLA radio image shows jets at least 3 light-years long emerging from the Great Annihilator. The jets seem to be streams of electrons and their antimatter counterparts, positrons.*

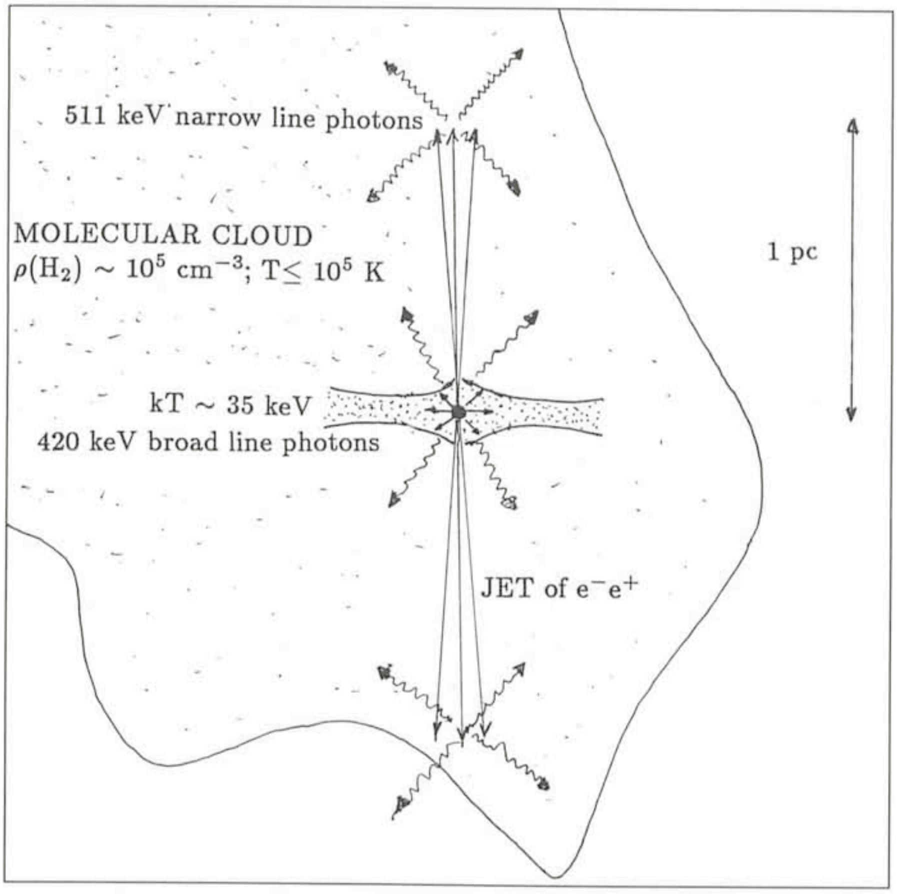

Figure 3: *Theoretical model of the Great Annihilator, possibly a stellar-mass black hole in a molecular cloud. Electron-positron pairs will annihilate sporadically within a few hundred kilometres from the black hole producing the redshifted broad emission line centred at 420 keV observed by SIGMA. Some fraction of the pairs will stream out at high velocities up to distances of ~ 1 pc before they are slowed down in the high density molecular gas, and annihilate giving rise to the 511 keV narrow line.*

tially transparent for the 511 keV annihilation photons.

Although the source of positrons at the origin of the broad line and the variable component of the narrow line may be the same, the annihilation medium of the narrow line must be different from that of the broad line. The redshift upper limit of 10^{-5} and the line width smaller than 5 % indicate that this narrow line is arising in a cold ($\leq 10^5$ K) and high density medium ($n \geq 10^4$ cm^{-3}). These properties are consistent with those of molecular clouds which have temperatures below 100 K, and densities greater than 10^4 cm^{-3}. In this context one may ask if the Great Annihilator could be a black hole in a molecular cloud.

3. A Black Hole Passing Slowly Through a Dense Molecular Cloud?

To answer this question we carried out observations of molecular transitions at millimetre wavelengths with the 30-m telescope of IRAM in the Sierra Nevada, southern Spain. The observations revealed the presence of a molecular cloud in the direction of the Great Annihilator[5]. The radial velocity indicates that this molecular cloud is in the galactic centre region, has a total mass of 50,000 solar masses and a mean density of 10^5 cm^{-3}. The absorption in soft X-rays along the line of sight to the Great Annihilator suggests that the compact source could be inside or near the foreground surface of this cloud. Although the physical association of the gamma-ray source and the molecular cloud has not been demonstrated, the probability of a coincidental superposition is less than 7 %.

To build up a model of the phenomenological diversity associated to the Great Annihilator we use a cartesian approach, going from a simple picture to a more complex one. This simple picture, which at present is full of unanswered questions is shown in Figure 3. Instabilities in the accretion disk around a stellar-mass black hole produce an enhancement of gamma photons, which by γ-γ interactions produce bursts of e^+e^- pairs that will annihilate within a few hundreds of kilometres from the black hole, producing the broad line observed by SIGMA. Some fraction of the e^+e^- pairs will be accelerated by radiation pressure, and collimated by magnetic fields. These pairs streaming away at relativistic velocities will produce the well-aligned synchrotron radio jets observed with the VLA over a few light-years of distance from the central source. The positrons will be slowed down in high density clumps of the molecular cloud with the subsequent annihilation that gives rise to the time variable narrow line.

When it is not fed, a black hole remains silent. Besides its gravitational effects it can reveal its existence as a source of high-energy photons and particles produced at or near an accretion disk built at the expense of matter coming from a binary companion. For instance, Cygnus X-1, one of the best black hole candidates has a blue supergiant companion that feeds the black hole by its strong stellar wind. Other black-hole candidates are fed by low-mass stellar companions, which transfer mass through the Roche lobes to the accretion disk of the black hole.

P.A. Duc from Saclay and I have used IRAC2 on the 2.2-m telescope at La Silla in an attempt to identify a binary companion. We obtained J, H, and K images of the field centred at the position of the VLA compact source, which we know with a precision better than 1″. Despite the high density of optically absorbed stars in the field, Figure 4 shows no infrared counterpart within 1″ of the radio counterpart down to mag K = 17. This is comparable to the result obtained by Djorgovski et al.[7] at Palomar. For an optical absorption of 50 mag along the line of sight to the galactic centre, this infrared magnitude limit implies that the Great Annihilator is not accompanied by a massive star, as is the black hole in Cygnus X-1. Conservative calculations show that no massive star with optical luminosity brighter than $M_V = -3$ mag is associated with the high energy source.

Since it is difficult to explain the light curve of the Great Annihilator observed by SIGMA[1] in terms of feeding from a low-mass companion, we envisage the possibility that the compact source is fed directly from the interstellar cloud by a classic mechanism first proposed by Bondi and Hoyle[8]. We have shown[5] that a compact object of stellar mass slowly moving through a dense molecular cloud can accrete more than 10^{-8} solar masses per year, namely, the equivalent of the accretion rate from the stellar wind of a massive companion.

In the context of this hypothesis one may ask why only a single powerful source of high-energy emission and annihilation occurs within the inner few degrees of the Galaxy, where molecular gas is more abundant than anywhere else in the Galaxy, and where there is no reason to expect that massive stellar remnants are rare. According to our hypothesis, the unusual properties of the Great Annihilator are the result of two conditions, each of which has a small probability of being satisfied: first, that the object is located within a dense cloud, and second, that it has a relatively small velocity with respect to that cloud. Our calculations show that only one among the ~40,000 massive remnants within 200 pc from the centre of the Galaxy would satisfy the conditions required to produce a substantial accretion luminosity without a binary companion. Therefore, it is not surprising that despite the large amount of compact objects in the central region of the Galaxy, there is only one Great Annihilator.

Although this is a possible scenario from a theoretical point of view, we have not demonstrated that it also corresponds to reality. Therefore, it still remains an open question how the accretion disk of the black hole is actually fed.

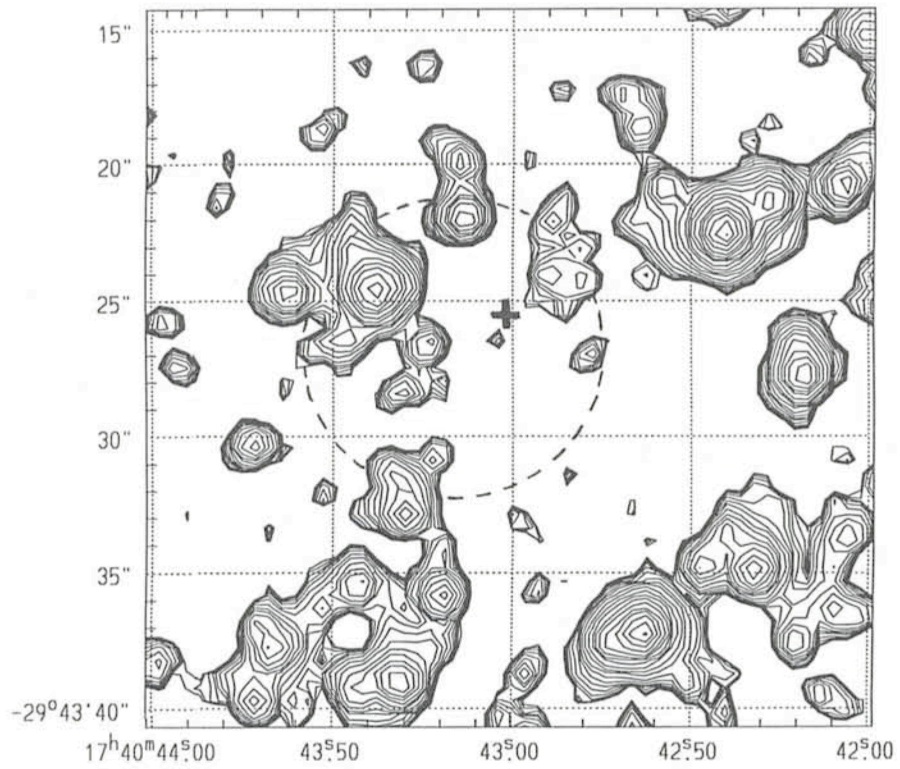

Figure 4: *K band image of the field in the direction of the Great Annihilator obtained with IRAC2 on the 2.2-m in June 1992. The ROSAT HRI X-ray error circle*[6]*, and the cross corresponding to the compact radio counterpart of the high energy source*[4] *are indicated. Within 1" of the VLA counterpart there is no infrared source down to mag K = 17. This implies that there is no massive star associated to the compact source more luminous than $M_V = -3$.*

4. A Second Microquasar in the Central Region of the Galaxy

After the Great Annihilator, the second strongest persistent gamma-ray source in the galactic centre region is the source GRS1758-258[1], which is located at galactic coordinates $l = 4.51°$; $b = -1.36°$. We have recently identified the compact radio counterpart of this gamma-ray source[9]. Infrared imaging with IRAC2 on the 2.2-m by P.A. Duc and the author shows that the field is less populated than that of the Great Annihilator. However, as for the Great Annihilator, we did not detect any K band counterpart to a limiting magnitude of 17.

The recent discovery[10] of equally symmetric radio jets emerging from the second strongest persistent gamma-ray source in the galactic centre region suggests that positron-electron pair jets may be common phenomena associated with high energy sources. Our observations suggest that this class of objects represents a scaled-down version of active galactic nuclei, which appear as "microquasar" stellar remnants in high density environments.

References

1 Cordier, B., 1992 Ph.D. thesis, Université de Paris VII.
2 Bouchet, L. et al. 1992, *ApJL*, **383**, L45.
3 Mereghetti, S. et al., 1992, *A&A* **259,** 205.
4 Mirabel, I.F., Rodríguez, L.F., Cordier, B., Paul, J. and Lebrun, F. 1992, *Nature* **358**, 215.
5 Mirabel, I.F., Morris, M., Wink, J., Paul, J., and Cordier, B. 1991, *A&A* **251**, L43.
6 Prince, T. et al. 1992, To be submitted to *ApJ*.
7 Djorgovski, G. et al. 1992, IAUC 5596.
8 Bondi, H. and Hoyle, F. 1944, *MNRAS* **104**, 21.
9 Mirabel, I.F. et al. 1992, IAUC 5655.
10 Rodríguez, L.F., Mirabel, I.F., Martí, J., 1992, *ApJL* **401**, L15.

ANNOUNCEMENT

ESO/OHP
WORKSHOP ON DWARF GALAXIES

A joint ESO/OHP Workshop on Dwarf Galaxies will be held from 6 to 9 September 1993, at the Observatoire de Haute-Provence (OHP) in France.

Topics of the workshop:
- Searches for dwarf galaxies
- Morphological classification
- Luminosity function
- Spatial distribution
- Detailed kinematical and dynamical studies
- Photometry and HR diagram
- Spectral synthesis
- Evolution and origin

Contact Address: Georges Meylan, European Southern Observatory, Karl-Schwarzschild-Straße 2, D-W8046 Garching bei München, Germany, e-mail (Internet): gmeylan@eso.org

Keeping an Eye on the X-Ray Sky

N. LUND, Danish Space Research Institute, Lyngby, Denmark

Introduction

Ground-based, optical observations of the counterparts of celestial X-ray sources are essential for the understanding of the physics of these sources. Since the typical X-ray source is quite inconspicuous in the optical, we need X-ray-sensitive wide-field monitors working in space to alert the ground-based astronomers to any unusual activity in the X-ray sky.

Most X-ray sources are highly variable, and many are in fact impossible to observe between their outbursts with present-day X-ray telescopes. On the other hand, during the outburst they can outshine the brightest persistent X- and gamma-ray sources, and new phenomena may become observable.

The WATCH Instruments

Since December 1989, three X-ray monitors built at the Danish Space Research Institute have been in orbit on board the Russian space observatory GRANAT. Since August 1992, a fourth instrument of the same type has been in operation aboard ESA's EURECA satellite. Each instrument covers about one quarter of the celestial sphere, and they are capable of locating strong X-ray sources within their field of view to a precision of about 45 arcminutes.

The instruments use a rotating shadow grid to modulate the signal from the X-ray sources, and the observed modulation function can be used to construct sky images (correlation maps) in a number of X-ray energy bands. This imaging technique is simple and requires only a small amount of data to be transmitted from the satellite, but the images require additional data treatment to extract weak sources in the presence of stronger ones. Around each source, and extending to the edge of the image field, is a sequence of circular ridges, slowly decreasing in amplitude (Fig. 1). Nevertheless, it is possible to clean away the sources sequentially, and in this way identify several sources in the same sky image. Another technique which has turned out to be particularly useful for the treatment of the EURECA data is the generation of global correlation maps, adding together data from many days with slightly different pointing. In these global maps the source sidelobes, visible in the individual images will be significantly suppressed (Fig. 2 and 3).

The rotation rate of the instrument modulators has been chosen so high, one revolution per second, that the instruments can localize also many of the so-called cosmic gamma-ray bursts. It is one of the primary objectives of the project to provide gamma-ray burst positions rapidly to observatories on the ground to enable a search for optical counterparts. An example of a correlation map based on only four seconds of data during a gamma burst is shown in Figure 4.

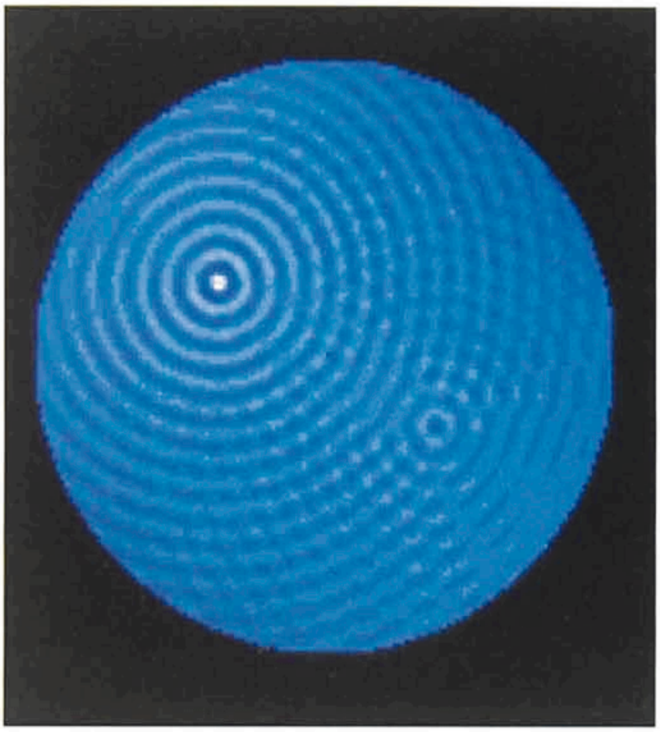

Figure 1: *A correlation map corresponding to 24 hours integration with the WATCH instrument on EURECA-I. Sco X-1, the brightest X-ray source in the sky, is dominating the image. The sidelobes of the strong source are completely hiding the images of other sources in the field. At least five of these sources can be identified once the Sco X-1 signal has been removed. The energy range is 6 to 8 keV; the lowest energy band accessible to WATCH. The full image is 130 degrees across.*

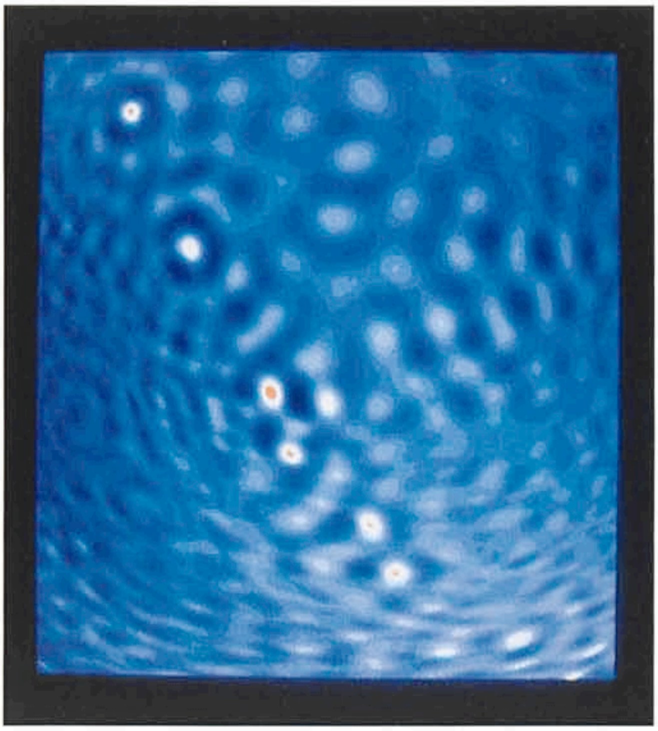

Figure 2: *Global correlation map corresponding to 30 days of integration with WATCH-EURECA. The image is composed of about 90 individual eight-hour maps. In the data processing the signals from the three strongest sources in each sub-image were subtracted before combining the sub-images. Thus Sco X-1 is completely removed, and the two next brightest sources for any given period are reduced in intensity in this composite picture. The eight sources visible are from top left to bottom right: Cyg X-1, GRS 1915+105, GX 17+2, GX 9+9, GX 5-1, 4U 1700-37, GX 340+0 and Cir X-1. The energy range is from 6 to 8 keV. The image covers from 14 h to 21 h in right ascension and from −65 to +45 degrees in declination.*

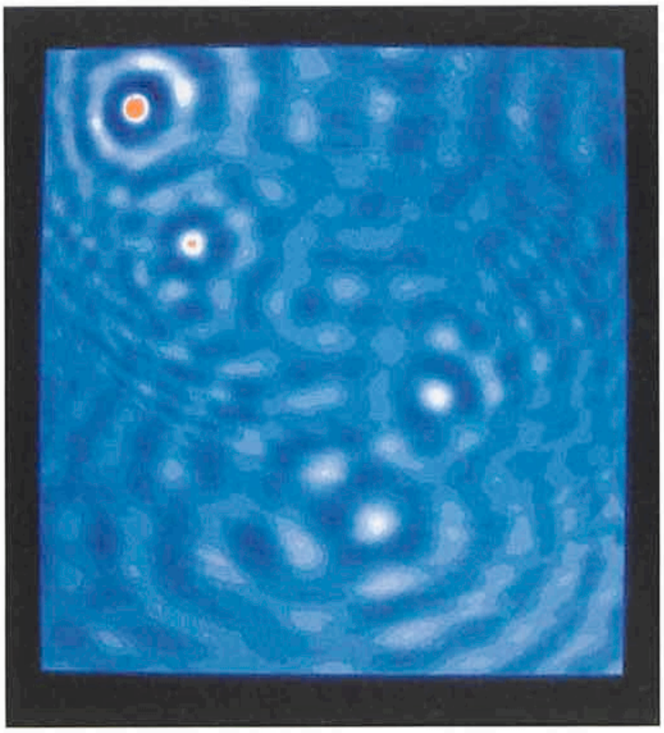

Figure 3: *As Figure 2, but here the energy range is from 15 to 25 keV. No subtraction of strong sources has been performed, so the sources appear with their correct relative intensities. At these higher energies Cyg X-1 (a black hole candidate) is by far the strongest source, while Sco X-1 (at right centre) is rather insignificant. GRS 1915+105 (an unidentified hard X-ray transient) and 4U 1700-37 are also visible.*

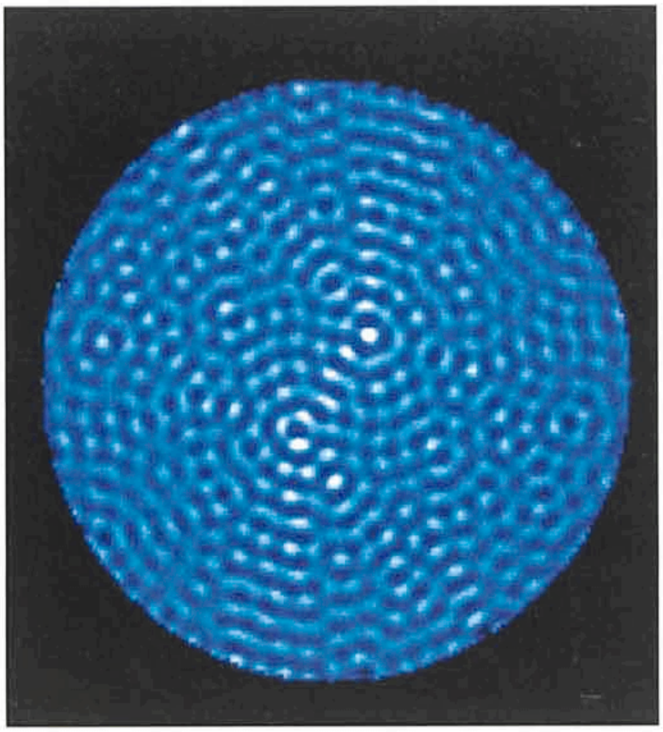

Figure 4: *The cross correlation map of a cosmic gamma burst observed with GRANAT-WATCH. This image corresponds to only 4 seconds of integration. Despite the noisy image the burst source position can be determined. Before a gamma-burst position is accepted we require several independent images like this one. The energy range here is 6 to 8 keV.*

X-Ray Novae

One class of X-ray transients where optical follow-up of space observations have been particularly rewarding are the X-ray novae. The most recent such events are GRS 1124-683 (Nova Muscae 1991) and GRO J0422+32 (Nova Persei 1992).

Nova Muscae was discovered in January 1991 by one of the WATCH detectors on GRANAT, and, independently, by the Japanese GINGA satellite (Lund and Brandt, 1991, Makino et al., 1991). The uncertainty in the early X-ray positions were too large to allow effective follow-up in the radio- or UV-range, but, in the optical, the ESO Schmidt group began a search for a counterpart. Simultaneously, preparations got underway to reorient the GRANAT spacecraft to allow the Russian ART-P and the French SIGMA telescopes to observe the source. These X- and gamma-ray telescopes have sufficiently large fields of view to be able to cover the WATCH error box. As it were, a candidate counterpart was identified first at ESO (Della Valle et al., 1991) and the association of the ESO candidate with the new X-ray source was confirmed a few days later by the ART-P and SIGMA observations (Sunyaev et al., 1991). The accurate position provided by the ESO team paved the way for a major observation campaign covering all wavelengths from radio to gamma-rays. The early results of this campaign were discussed at a workshop at the Danish Space Research Institute in May 1992 (Brandt, 1992).

The observations of the recent Nova Persei 1992 have followed a very similar pattern. Originally discovered as a strong X-ray source by the BATSE instrument on NASA's COMPTON satellite (Paciesas et al., 1992) the object was optically identified from the Crimean Astrophysical Observatory making use of an improved X-ray position provided by WATCH. (Castro-Tirado et al., 1992 a, 1992 b). Following the optical identification a steady stream of IAU Circulars have testified to the breadth of the ongoing observation campaign.

Simultaneously with the optical identification of Nova Persei 1992 another bright X-ray transient, GRS 1915+105, was discovered by WATCH (Castro-Tirado et al., 1992 c). Unfortunately no optical counterpart for this source has as yet been identified despite intensive search both at ESO and at Crimea. Even the availability of a much improved X-ray position from the SIGMA experiment has not resulted in finding a counterpart. This source is located right in the Galactic plane and apparently the object is hidden behind dust clouds. Consequently our knowledge about this source is likely to remain quite limited. Jugded from the X-ray spectrum alone, this source may also be different from the X-ray novae discussed above.

The X-ray novae are exciting objects because they seem to be our major source of information concerning black holes in our Galaxy. Since 1975 where the British ARIEL-V satellite discovered the first X-ray nova (Elvis et al., 1975), a total of six have been observed. In all cases the eruption appears to come from a binary system in which a dwarf star of spectral type G or later orbits a massive compact object. The masses of the compact objects have been determined by optical observations of the systems in quiescence, and they all exceed the theoretically predicted maximum masses for stable neutron stars, thus they must be assumed to be black holes. The X-ray spectra observed during the outbursts are quite variable but in all cases the sources have, at times, exhibited power-law-like spectra without sharp cut-offs toward the high energy end. Such spectra are also present from time to time from Cyg X-1, a persistent X-ray source also believed to harbour a black hole. A major surprise, which may be very important also for our understanding of some of the X-ray sources near the galactic centre, was the observation from Nova Muscae 1991, of a relatively short duration episode of intense emission of electron-positron annihilation radiation (Ballet et al., 1992).

Gamma-Ray Bursts

This is a branch of X-ray astronomy where optical follow-up so far has yielded only negative or inconclusive results. The importance of finding counterparts in any waveband is however so obvious, that the search has to be continued and improved despite all disappointments in the past. The confusing situation regarding our (lack of) understanding of these enigmatic events has recently been discussed in this journal (Boer et al., 1992), so here only the main points will be mentioned: The bursts appear isotropically distributed over the sky, yet they are not homogeneously distributed in space since the number of bursts does not increase as rapidly as the volume of space accessible by instruments of different sensitivity. There are simply not enough weak bursts observed (Meegan et al., 1992). The burst durations span the range from tens of milliseconds to hundreds of seconds with a great variability of time structures and no obvious subclasses. The X-ray energy spectra are extremely hard, extending far up in the gamma-ray regime. In fact, the bursts are so deficient in soft X-rays that they cannot originate close to any stellar surface (Imamura and Epstein, 1986) – still some of the bursts exhibit lines in the X-ray spectra very reminiscent of the cyclotron resonance lines thought to be associated with strong magnetic fields surrounding neutron stars.

No model has been put forward as yet which can encompass all these apparently conflicting bits of evidence. And so far our only information channel are the X- and gamma-ray data. To progress further we must find new ways of observing emissions from the gamma-burst sources.

WATCH was one such attempt of designing an instrument which could provide positions useful for Schmidt camera follow-up with a minimal delay. But the average detection rate of gamma-bursts with WATCH has been only one per month or less, and in practice the delay between the localization of a burst by WATCH and the exposure of a Schmidt plate is typically 48 hours or more. These exposures are definitely interesting even if no object can later be found, because they set important constraints for the source models. Particularly if the bursts are assumed to originate at cosmological distances they must involve energy releases corresponding to supernova explosions and the absence of optical emission a few days after the event is disturbing. But, of course, the identification of one real counterpart would be a lot more fun than ten interesting non-detections!

Outlook for the Future

Both the WATCH instruments and the BATSE instrument will continue to provide rapid but rough gamma-burst locations for some time to come. Combining data from these instruments with those from space probes such as ULYSSES will yield more accurate positions, but with some time delay. The next improvement in the space segment may come with the launch in 1994 of HETE, a small satellite carrying conventional gamma-burst instrumentation supplemented with X-ray and UV cameras. The positions determined by HETE will be accurate to some arcminutes based on the X-ray camera and accurate to maybe 0.1 arcminute if sufficient UV emission is present to allow the UV cameras to pick up the source. The main limitation of the HETE cameras is that they cover effectively less than 10 % of the sky. But, as stated above, one good catch will be worth a lot.

On the ground, the availability of large-format CCDs for astronomical research will no doubt improve the prospects of searching for counterparts of transient X-ray sources. Such CCDs when mounted on suitable telescopes could provide a field of view matching the limited precision of the X-ray positions. The gain in sensitivity and ease of data analysis should allow much more rapid and effective searches to be performed. An alternative route, hopefully to be exploited in space astronomy, is to supplement a wide field X-ray monitor with gimballed X-ray and optical precision telescopes on the same satellite. But, with the established development times for space instrumentation, the ground observers are likely to have still another 10 years to find the elusive sources of the cosmic gamma bursts.

References

Lund, N., 1985, In: X-ray Instrumentation in Astronomy, ed. J.L. Culhane, *SPIE* **597**, p. 95.
Lund, N. and S. Brandt, 1991, IAU Circ. 5161.
Makino, F., 1991, IAU Circ. 5161.
Della Valle, M., B.J. Jarvis and R. West, 1991, IAU Circ. 5165.
Sunyaev, R., E. Jourdain and P. Laurent, 1991, IAU Circ. 5176.
Brandt, S. (editor), 1991, Proceedings of the Workshop on Nova Muscae 1991, DSRI Report 91-2. 1991.
Paciesas, W.S., M.S. Briggs, B.A. Harmon, R.B. Wilson and M.H. Finger (1992), IAU Circ. 5580.
Castro-Tirado, A.J., S. Brandt and N. Lund (1992 a), IAU Circ. 5587.
Castro-Tirado, A.J., E.P. Pavlenko, A.A. Shlyapnikov, R. Gershberg, V. Hayrapetyan, S. Brandt and N. Lund (1992 b), IAU Circ. 5588.
Castro-Tirado, A.J., S. Brandt and N. Lund (1992 c), IAU Circ. 5590.
Elvis, M., C.G. Page, K.A. Pounds, M.J. Ricketts and M.J.L. Turner (1975), *Nature*, **257**, p. 656.
Boer, M., C. Motch, H. Pedersen, S. Brandt, A.J. Castro-Tirado, N. Lund and A. Smette (1991) *The Messenger*, **66**, p. 61.
Meegan, C.A., G.J. Fishman, R.B. Wilson, W.S. Paciesas, M.N. Brock, J.M. Horack, G.N. Pendleton and C. Kouvelioutou, (1992) IAU Circ. 5641.
Imamura, J.N. and R.I. Epstein (1987), *Ap.J.* **313**, p. 711.

Looking Through the Dust – the Edge-on Galaxy NGC 7814 in the Near-Infrared

R. F. PELETIER, ESO; J. H. KNAPEN, IAC, Tenerife, Spain

1. Introduction

To study the photometric and morphological properties of spiral galaxies like our own, large nearby galaxies, which are assumed to be characteristic, are usually investigated in detail. To study the radial properties of galaxy disks, one looks at galaxies with a low inclination angle, while the vertical distribution of gas and stars is studied in highly inclined galaxies.

A complicating factor for the investigation of edge-on galaxies is extinction by dust in the disk. Apart from S0 galaxies, whose disks might be transparent, the disks of most edge-on galaxies are opaque in the inner regions in optical

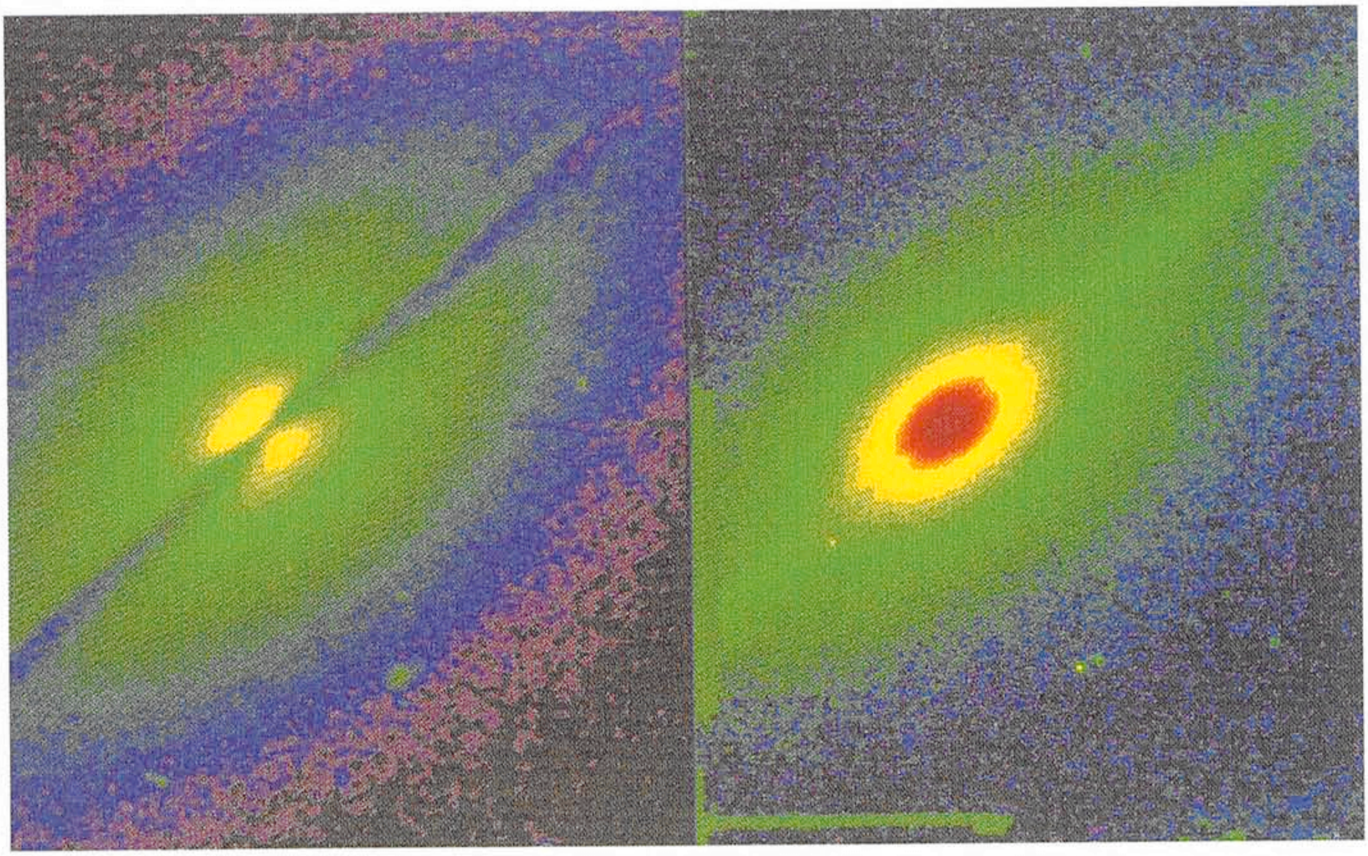

Figure 1: *Images of NGC 7814 in V (left) and K′ (right) on the same scale. The size of both fields is 100″ × 140″. N is up and E to the left. The bar at the bottom of the infrared image is caused by a bad column in the detector.*

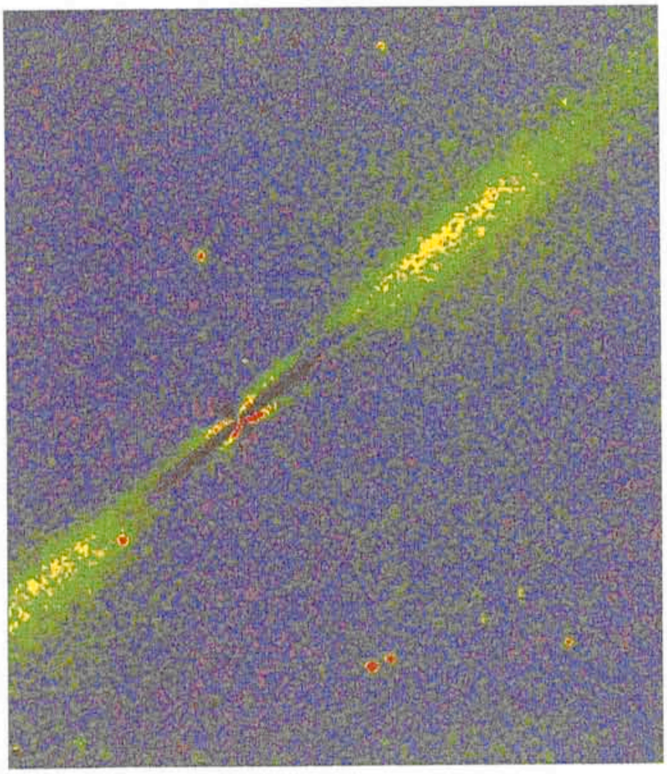

Figure 2: *K′ image of the stellar disk in NGC 7814. The field is the same as in Figure 1. This image was made by fitting ellipses outside the region of the disk, extrapolating them, and subtracting them from the galaxy. One can see that even in K′ some of the stellar light is being absorbed.*

Figure 3: *J-K′ colour map of NGC 7814. J and K′ were chosen because the seeing in those bands was the best. The field is the same as in Figure 1. Darker colours here indicate redder colours.*

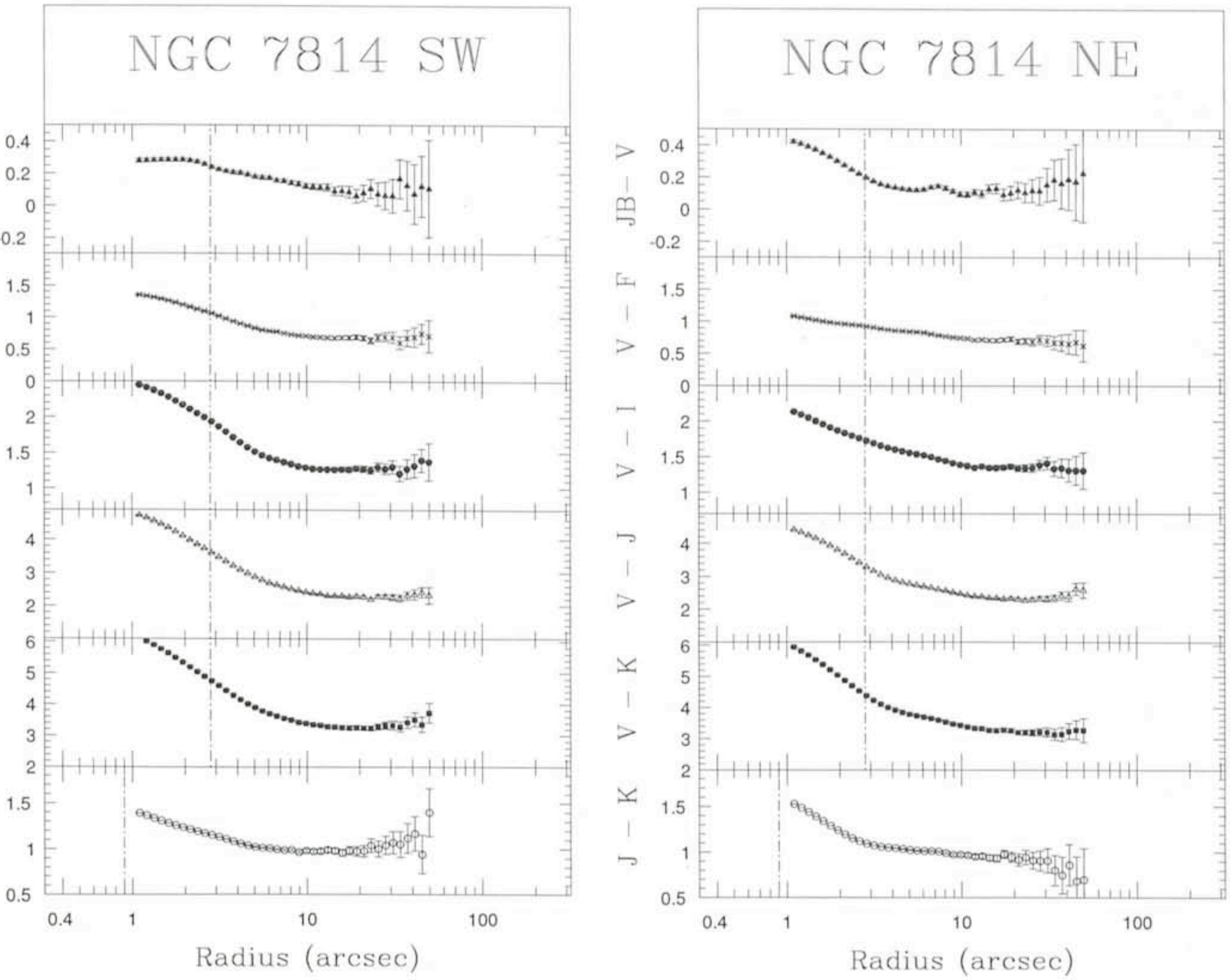

Figure 4: *Colour profiles determined in a wedge of 60° along the minor axis through the bulge. The optical colours are on the system defined by Schild and Kent (1981), where JB lies between B and V, and F is more or less equal to Cousins R. Note the large gradients towards the centre and the constancy of the colour outside 10″.*

bands like B and V. This makes the determination of the z-distribution of the stars, as well as the light distribution of the bulge, very difficult. Although for edge-on galaxies it is easy to separate bulge and disk, it is difficult to know how much extinction is present in front of the bulge.

One of the great advantages of going to the near-infrared (NIR) is that the extinction by dust is much smaller (e.g. Schultz and Wiemer 1975). In the K-band at 2.2 μm, $A_K/A_V \approx 0.11$ in our Galaxy (Rieke and Lebofsky, 1985), and this ratio for large external spirals is likely to be similar (Knapen et al., 1991). So by observing an edge-on spiral in the NIR, we can study the properties of the stars of both bulge and disk much better.

For a few months ESO has an instrument-telescope combination that offers the large field of view and the good sampling in the NIR that is needed for the study of large nearby spirals, namely IRAC2 on the 2.2-m (Moorwood et al., 1992). We have used this combination to study the Sa galaxy NGC 7814, a system with a large bulge and a disk that is very close to edge-on. This galaxy has been investigated before by Van der Kruit and Searle (1982), who found large colour variations as a function of radius in the bulge, which they interpreted as metallicity gradients. This result, as well as the aperture photometry of Wirth and Shaw (1983) was taken as evidence that metallicity gradients in bulges are common.

2. Observational Details

NGC 7814 was observed in September 1992 in the J (1.2 μm) and K′ (2.1 μm) filters. Because of the good seeing (0.9″) we chose to observe it in two magnifications, namely LC (0.49″/pixel) and LB (0.27″/pixel). During this run a best seeing of 0.70″ (FWHM) was reached. The galaxy was observed in 4 different positions on the array in each band and magnification, interleaved with 4 exposures of the sky background. This was done to get rid of bad pixels and to be able to cancel out sensitivity variations across the chip. We thus obtained better flatfields than by using only the calibration exposures on the dome. The reduction and analysis was done in Garching, where the IR data were also compared with optical CCD frames taken by R. Schild at the F. L. Whipple Observatory in Arizona. In Figure 1 we show the images in K′ and V both on the same scale. The dust lane is much more clearly visible in V, but the resolution in K′ is much higher.

3. Properties of the Disk

To separate bulge and disk in K′ we first removed the region of the disk outside the central area ($r \geq 20''$ and $|z| \leq 10''$), fitting ellipses as a function of radius in the remaining area, and extrapolating and subtracting the contribution of those ellipses in the region of the disk (see Fig. 2). This method leaves

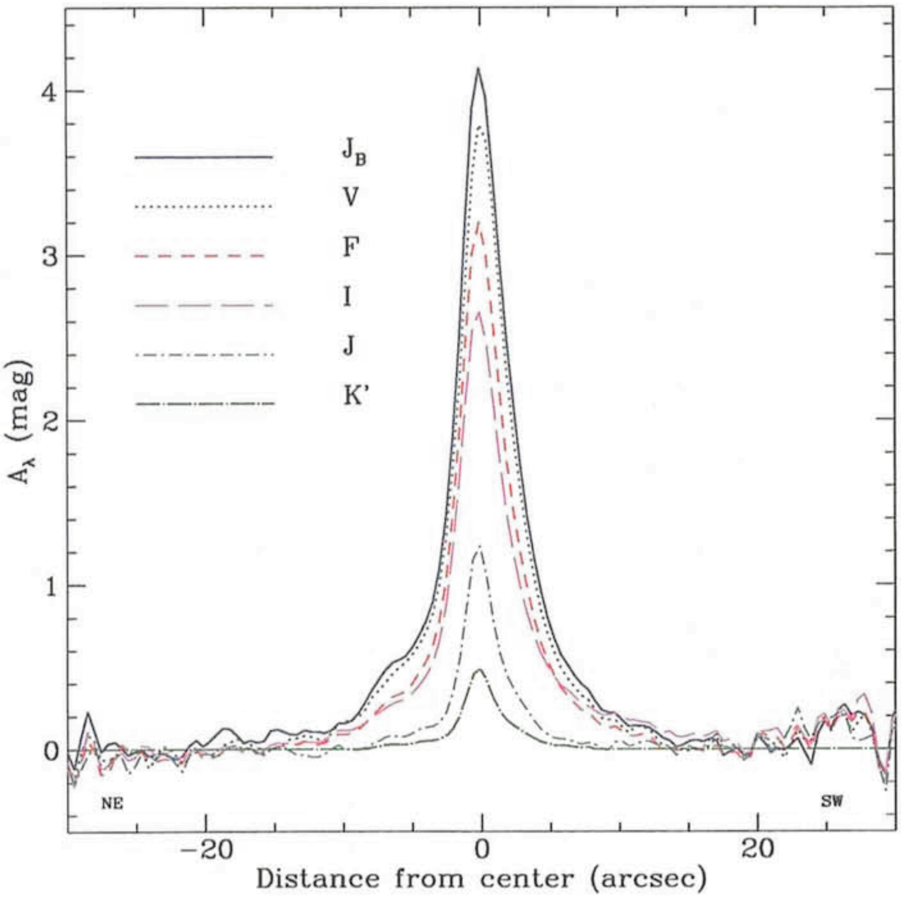

Figure 5: *Profiles of the extinction along the minor axis, calculated in a band with a width of 1.5″. The same colours are used here as in Figure 4.*

a "hole" in the disk in the centre, which is probably unrealistic, but the fact that our isophotes here are boxy (e.g. Carter, 1979) shows that the contribution of the disk at any radius is less than 0.5% of that of the bulge.

One sees a sharp absorption band, which also makes the disk in the outer regions asymmetric. It shows that extinction, although insignificant, is still present in K′. We measured the thickness (FWHM) of the disk at several positions and find values between 7 and 10″, with an average of 9″, which would correspond to 480 pc if this galaxy were at 12 Mpc, a distance obtained from the Tully-Fisher relation (Aaronson et al., 1980). Exponential fits also give an average scale height of 9 ± 1″. Our galaxy has a scale height of ≈ 200 pc (Kent et al., 1991), which implies that the disk of NGC 7814 is thicker, or that the disk is inclined. Assuming a diameter of 8′, as obtained from the HI (Van der Kruit and Searle, 1982) the disk cannot be inclined by more than 1°.

The dust lane itself is thinner than the disk. In the J – K′ colour map, shown in Figure 3, the thin absorption band is seen across the whole disk. The FWHM of the dustlane varies between 3.1″ and 4.6″, more than a factor 2 smaller than the thickness of the disk. This can be understood if the dustlane, as in our Galaxy, is associated with the young stars, which have a much smaller vertical scale height. For NGC 7814 we find that the thickness of the dust distribution lies between 0.33 and 0.5 times the thickness of the distribution of old stars producing the K′ light. For spiral galaxies one would expect such a ratio from the relation between surface brightness and inclination (see Peletier and Willner, 1992).

4. Properties of the Bulge

The fact that NGC 7814 is relatively nearby and has a large bulge makes it, just like the Sombrero, a prime candidate for the study of stellar population gradients in bulges. It is in general not possible to determine from colours alone whether gradients are caused by extinction by dust or by metallicity variations. Secondary, morphological arguments can however sometimes be used; usually one can detect dust because it shows a patchy distribution. For NGC 7814 it is clear that the reddening in the disk is caused by extinction. It is clear from the colour map (Fig. 3) that the colour variations outside the disk are much smaller. We have determined the colour profiles in a number of optical and NIR colours in a wedge along the minor axis with an opening angle of 60°, and plotted them in Figure 4.

Large colour gradients are seen within 10″ from the centre, but at larger radii the colours are constant. Extinction by dust, also because the colour profiles on the NE and SW side are not symmetric. Some minor metallicity change within 10″ can however not be excluded. In a recent survey Balcells and Peletier (1992) find that the stellar population gradients in bulges are similar to those in ellipticals of the same luminosity. NGC 7814 agrees with this, because its bulge luminosity is $M_B = -19.1$ (at 12 Mpc), and elliptical galaxies of that luminosity usually do not display any metallicity gradient. If this result for bulges turns out to be general, it shows that the mechanism that formed the disk has not perturbed the bulge in general, implying that it happened later, and gradually.

We have calculated extinction profiles along the minor axis. Since the centre of the galaxy is obscured by the dust lane, we cannot simply subtract the obscured half of the disk from the unobscured half, as in the case of the Sombrero galaxy (Knapen et al., 1991). Here, we have estimated the unobscured profile from the profile in K′, using the J – K′ profile and the galactic extinction law (which is probably valid, see Knapen et al., 1991). The results are presented in Figure 5. Note the asymmetry in the dust profiles, well visible in images of NGC 7814 (see Fig. 1). The maximum edge-on extinction in the K′ band is 0.2 magnitude, in the B band it is some 4 mag. The bump in the profiles between 5″ and 10″ from the centre toward the NE may be caused by inhomogeneities, or alternatively by warping in the dust lane.

We can see from this example that with the new IRAC2 data it is now possible to perform a good decomposition of bulge and disk in spiral galaxies, and to determine some fundamental properties of both components due to the much reduced influence of dust extinction in the NIR bands.

References

Aaronson, M., Mould, J. R. and Huchra, J. P., 1980, *ApJ*, **237**, 655.
Balcells, M. and Peletier, R. F., 1992, in IAU Symposium 153, *Galactic Bulges*, Gent, 17-21 August 1992.
Carter, D., 1979, *MNRAS*, **186**, 897.
Kent, S. M., Dame, T. M. and Fazio, G. G., 1991, *ApJ*, **378**, 131.
Knapen, J. H., Hes, R., Beckman, J. E. and Peletier, R. F., 1991, *AA*, **241**, 42.

Moorwood, A., Finger, G., Biereichel, P., Delabre, B., Van Dijsseldonk, A., Huster, G., Lizon, J.-L., Meyer, M., Gemperlein, H. and Moneti, A., 1992, *The Messenger*, **69**, 61.
Peletier, R. F. and Willner, S. P., 1992, *AJ*, **103**, 1761.
Rieke, G. H. and Lebofsky, M. J., 1985, *ApJ*, **288**, 618.
Schild, R. and Kent, S. M., 1981, *Proc. SPIE*, **290**, 186.
Schultz, G. V. and Wiemer, W., 1975, *AA*, **43**, 133.
Van der Kruit, P. C. and Searle, L., 1982, *AA*, **110**, 79.
Wirth, A. and Shaw, R., 1983, *AJ*, **88**, 171.

Dark Matter in CL0017 (z = 0.272)

L. INFANTE, H. QUINTANA, G. HERTLING, M. WAY, P. Universidad Católica de Chile
P. FOUQUÉ, P. Universidad Católica de Chile and Observatoire de Paris
E. GIRAUD, ESO

1. Introduction

The motion of galaxies has been used to study the gravitational field around cluster cores and, thus, estimate their masses. An independent way to obtain the total mass in clusters is now available using gravitational lensing. In fact, gravitational arcs have become an additional test to probe not only the existence and amount of dark matter in clusters but also how this matter is distributed. (For a review see Tyson 1992).

Using recent results from observations of a medium-redshift rich cluster of galaxies, namely CL0017, we here make the case for one of the best candidates where to look for gravitational arcs. From spectroscopic data from 5 clusters at z ~ 0.3, we find that CL0017 meets all the necessary characteristics for a gravitational arc search: high mass, high M/L, medium redshift and extreme compactness.

2. Discussion

CL0017, a rich cluster at a redshift of 0.272, has turned out to be quite an interesting case. It was first discovered on deep CFHT prime focus plates by Infante et al. (1986). It is located near the South Galactic Pole and contains a giant galaxy at its centre, probably a cD galaxy. This galaxy is surrounded by several smaller galaxies in a disk-like configuration, all embedded in what seems to be a common, extremely compact, halo of diameter ~ $77h^{-1}$ kpc ($q_0 = 0$) and total absolute magnitude in V of −24.

The brightest members of this cluster are clearly very red (i.e. (B−V) = 0.9) as would be expected for a cluster dominated by E/S0 galaxies. However, a significant blue population of galaxies (with (B−V) < 0.7, which would correspond to later than Sab spirals) is also found, consistent with the findings of Butcher and Oemler (1984) of a higher fraction of blue to red galaxies in medium redshift clusters as compared to low z clusters.

The above results motivated more detailed photometric and spectroscopic observations of this cluster. In 1987 Quintana and Infante observed the central nucleus of this cluster with the 2.5-m Las Campanas Observatory 2DF spectrograph and obtained a velocity of 81435 ± 68 km/sec (z = 0.272). Later in 1991, Giraud acquired short B,V and R CCD exposures with EMMI on the NTT. As reported in Infante, Giraud and Triay (1991), an arc-like feature on all these deep images was confirmed. Although during the NTT observations the seeing was 0.9″, poor for NTT standards, the arc-like feature is quite conspicuous in all the frames. The arc is significantly bluer than the red cluster galaxies. Furthermore, images of the cluster have been obtained in a variety of bandpasses (V,R,I,g,r) on a number of telescopes (CTIO 4-m, ESO 2.2-m, LCO 1-m). A paper reporting the results is in preparation (Infante et al. 1992).

Here we report the results from our spectroscopic observations with EFOSC1 on the ESO 3.6-m telescope. The observations were carried out on three non photometric nights in December 1990. Two multiobject plates were used to obtain spectra of about 25 selected red galaxies. The aim was to determine a dynamical mass of the cluster, particularly of its core, and its mass-to-light ratio. The spectra were reduced twice; a preliminary reduction with IHAP software and then a final reduction using IRAF 2D spectral package (details in Infante et al. 1992). Both reductions gave consistent results.

In Figure 1 we show the distribution of velocities. After clipping out 3 sigma

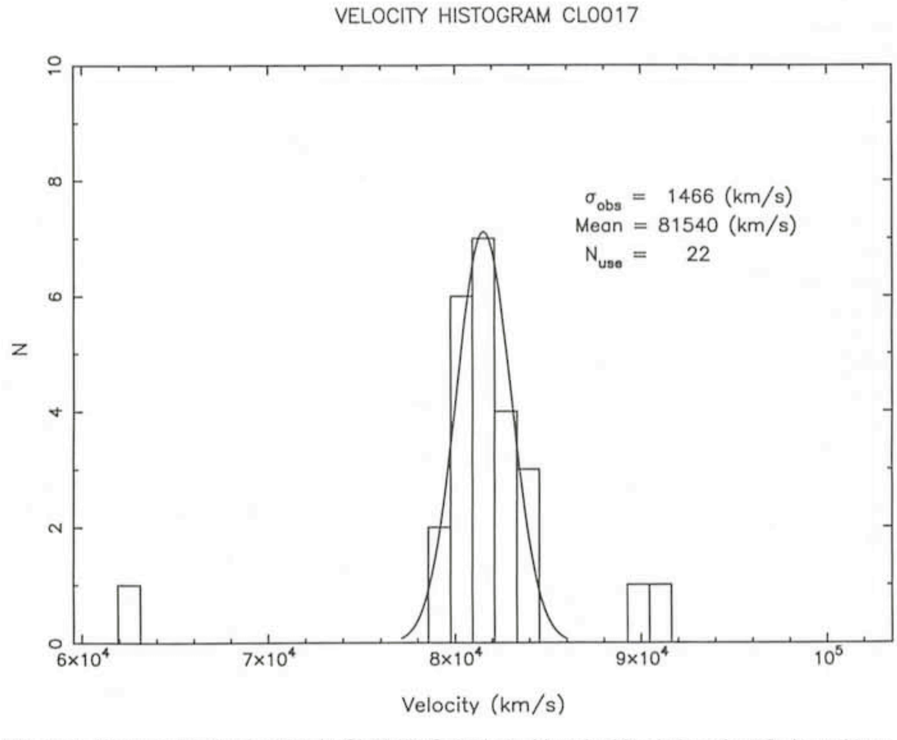

Figure 1: *Histogram of velocities in CL0017. Galaxies with velocities larger than 3σ* have been removed. 22 out of 26 galaxies remained. We also plot the best gaussian distribution to the points.

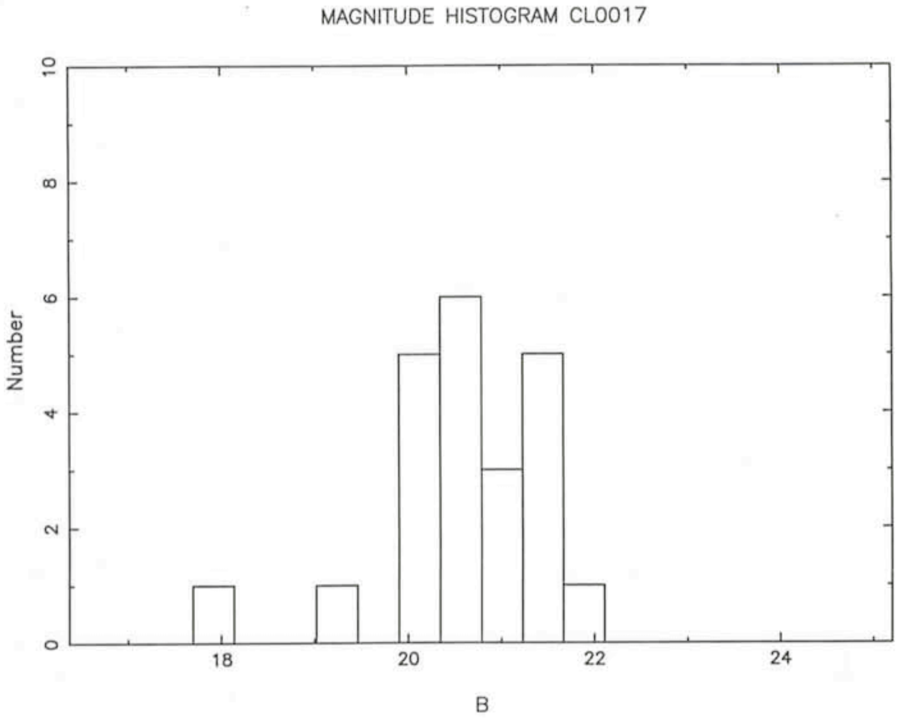

Figure 2: *Histogram of corrected B magnitudes.*

outliers 22 out of 26 galaxies remained. A Kolmogorov-Smirnov test which compares our distribution of velocities to a gaussian distribution returned a significance level larger than 95%. The uncorrected line-of-sight velocity dispersion and mean recession velocity are σ = 1466 $\mathrm{kms^{-1}}$ and υ = 81,540 $\mathrm{kms^{-1}}$ respectively.

We then applied the method described in Gourgoulhon et al. (1992) to determine the virial mass and mass-to-light ratio of the cluster. As the collapse time of the cluster (2 Gyr) is small compared to the Hubble time, the cluster is virialized, and its virial mass is a good estimator of its total mass.

We first correct our raw data for various effects: K-corrections are adopted from Pence (1976), and amount to −1.27 and −0.66 in the B and V-bands, respectively; evolutionary corrections are taken from Arimoto and Yoshii (1987) for a 10^{11} $M_\odot$ E/S0 galaxy, and amount to +0.34 and +0.08 for V-magnitudes and (B-V) colours, respectively; relativistic corrections to mass and mass-to-light ratio multiply uncorrected values by 0.42 and 0.35, respectively. The dependence of these corrections upon adopted values of H_o, q_o and z_f (redshift of formation) is small at the cluster redshift (0.272). Due to the location of the cluster (South Galactic Pole), galactic absorption is neglected; internal absorption is neglected as well, because most of our sample galaxies are early-type.

We obtain a corrected mass of 7.0×10^{14} $M_\odot$. For each galaxy, the uncorrected magnitude in the B-band is evaluated from Gunn g and r magnitudes, using Kent's (1985) relations. The corrected B-magnitude is then calculated adding $-1.27+(0.34+0.08) = -0.85$. The mean observed colour is $g-r = 0.90$, corresponding to $B-V = 1.46$. Applying the K-and evolutionary corrections to this value gives a corrected B−V at redshift 0 of 0.93 (typical of E/S0 galaxies), confirming the order of magnitude of these corrections. The total luminosity of the cluster in the B-band is obtained after correction for the contribution of faint members not measured. To make this correction, we integrate a Schechter luminosity function from the limiting magnitude of a complete sub-sample down to infinity. Figure 2 shows that our sample of 22 galaxies is complete down to a corrected B-magnitude of 20.8. Adopting a luminosity distance of 1200 Mpc, the correcting factor for incompleteness is 2.18. As the total luminosity of the galaxies brighter then 20.8 is 3.9×10^{11} $L_\odot$, we adopt a total luminosity of the cluster of $8.5 \times 10^{11} L_\odot$, corrected for relativistic effects and incompleteness. 20% of this luminosity is concentrated in the nucleus.

Finally, we derive a mass-to-light ratio in the B-band of 820 $M_\odot/L_\odot$.

3. Conclusions

Rich, compact and massive galaxy clusters at redshifts between 0.2 and 0.5 with line of sight velocity dispersions exceeding 700 km/s are good gravitational lens candidates. They distort background galaxies which are as far as twice the cluster distance. The magnification and distortion of these galaxies provide an independent method to detemine cluster masses and to study objects at high redshifts.

CL0017 is one of the best lens candidates available. It possesses a mass of 7.0×10^{14} $M_\odot$ and a luminosity of 8.5×10^{11} $L_\odot$ ($M/L = 820$ $M_\odot/L_\odot$), much of it in a very compact nucleus of size $77h^{-1}$ Mpc. Because of its high mass and high M/L ratio, CL0017 becomes an excellent candidate to search for multiple arcs and, therefore, probe the dark matter independently.

References

Arimoto, N., Yoshii, Y. 1987, *A&A*, **173**, 23.

Butcher, H., and Oemler, A. 1984, *Ap. J.*, **285**, 426.

Gourgoulhon, E., Chamaraux, P., Fouqué, P. 1992, *A&A*, **255**, 69.

Infante, L., Giraud, E., and Triay, R. 1991, *The Messenger*, **64**, 65.

Infante, L., Pritchet, C.J., and Quintana, H. 1986, *A. J.*, **91**, 217.

Infante, L., Giraud, E., Quintana, H., Way, M., and Hertling, G. 1992, In preparation.

Kent, S.M. 1985, *P.A.S.P.*, **97**, 165.

Pence, W. 1976, *Ap. J.*, **203**, 39.

Tyson, A. 1992, *Physics Today,* Vol. **45**, No. **6**, 24.

New Features of IRSPEC

R. GREDEL and U. WEILENMANN, ESO La Silla

In January 1991, IRSPEC at the NTT was equipped with a 58×62 pixel InSb array from Santa Barbara Research Center (SBRC). The chip replaced a 1D array and brought new observing features such as long-slit capability. The new system is discussed in the March 1991 issue of *The Messenger* **63,** p. 77. IRSPEC has been further improved in the meanwhile. Recent instrumental modifications have resulted in a higher sensitivity in the 1 – 2.5-μm region. Operational enhancements such as the implementation of automatic beam-switching and continuous mode have increased the efficiency of observations with IRSPEC. The modifications were carried out by Peter Biereichel, Gert

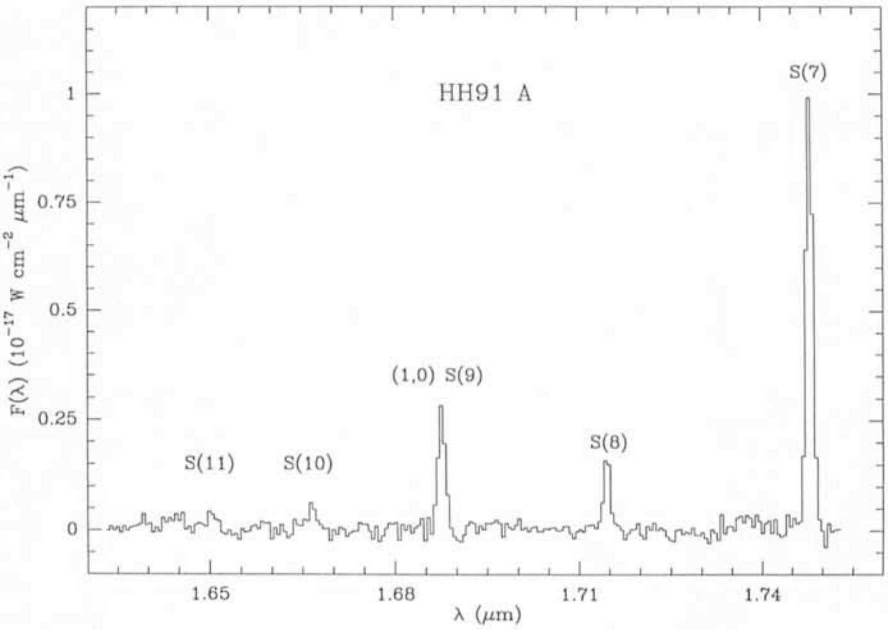

Figure 1: *H-band spectrum of the Herbig-Haro object HH 91A. Monochromatic fluxes in units of 10^{-17} W cm^{-2} μm^{-1} are plotted vs. wavelength λ in μm. Individual rotational transitions that arise in the S-branch of the (1,0) band of H_2 are identified.*

Finger, Manfred Meyer and Jean-Louis Lizon from Garching, and Flavio Gutiérrez and one of the authors (U.W.) from La Silla.

The following contains a discussion of the recent instrumental changes and the new observing modes that are now available. It also summarizes some of the scientific results obtained with IRSPEC during the last year to illustrate the applications of the instrument.

Instrumental Enhancements

In April/May 1991, non-destructive multiple readout was installed as part of the data-acquisition software. In this mode, the output voltages of the pixels are continuously sampled at a rate of 19 s^{-1} without resetting. A linear regression is fit through the individual "readouts", which results in a significant reduction of the effective read-noise. Several measures were taken to suppress the internal background, including screening of the light path and blocking of remaining light leaks in the cold shield. In J, H and K, these measures have reduced the RMS noise to less than 200 e for detector integration times (DITs) of a few tens of seconds. For DITs longer than about a minute, the noise increases due to shot noise. Other hardware modifications included modifications of various components of the opto-mechanical functions, such as the grating exchange mechanism, which caused some trouble in the past. Only one of the previously reported shortcomings remains: about 20 % of the slit remains vignetted by the filters which were not sized for the SBRC array. Given the fact that the usable length of the slit is about 100″, however, this drawback does not influence observations with IRSPEC.

New Observing Modes

The software that handles the spectrometer setting was rewritten and transferred from an old HP 1000 to the main HP A900 instrument computer. Spectrometer and instrument parameters are set via form filling or through typed commands. In April 1992, two new observing procedures, *continuous mode* and *beam switching*, were implemented. It is now possible to obtain a full spectrum with specified beginning and end wavelength and the respective sky frames automatically. The pixel overlap between adjacent spectral segments, the number of object-sky pairs per grating setting, and the reference position can be entered as well. The system then performs the given number of integrations per grating setting, offsets the telescope to obtain explicit sky measurements, if desired, and steps the grating successively through the given wavelength range to obtain the full spectrum. The automatic observing procedures not only remove overheads that were introduced in the past when many of these steps had to be performed manually. They also eliminate a source of error and make sure that the observer leaves La Silla with a complete set of measurements, without sky frames missing or gaps in his or her spectra.

In the future, it is expected to increase the wavelength encoder resolution from presently 2.6 encoder steps per pixel by about a factor of 4. Thus, settings to particular wavelengths will become more reproducible. A transfer of IRSPEC data to a SUN workstation is planned to allow on-line data reduction using existing MIDAS routines.

Scientific Results

HH 90/91. Figures 1 and 2 show the H- and K-band spectra obtained to-

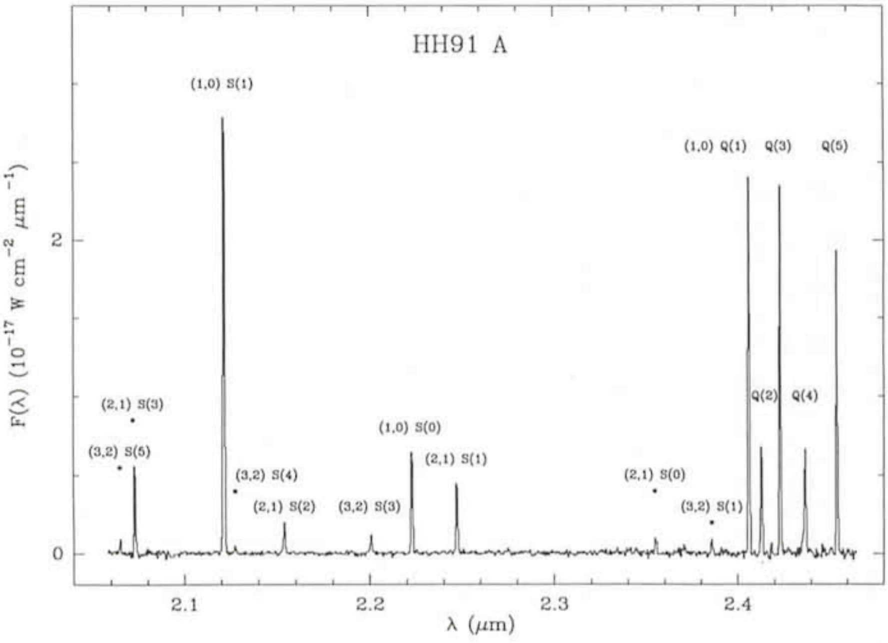

Figure 2: *K-band spectrum of HH 91A. Labels as in Figure 1. The spectrum is a composite of 16 individual segments obtained with an integration time of 8 min each, equally shared between object and sky.*

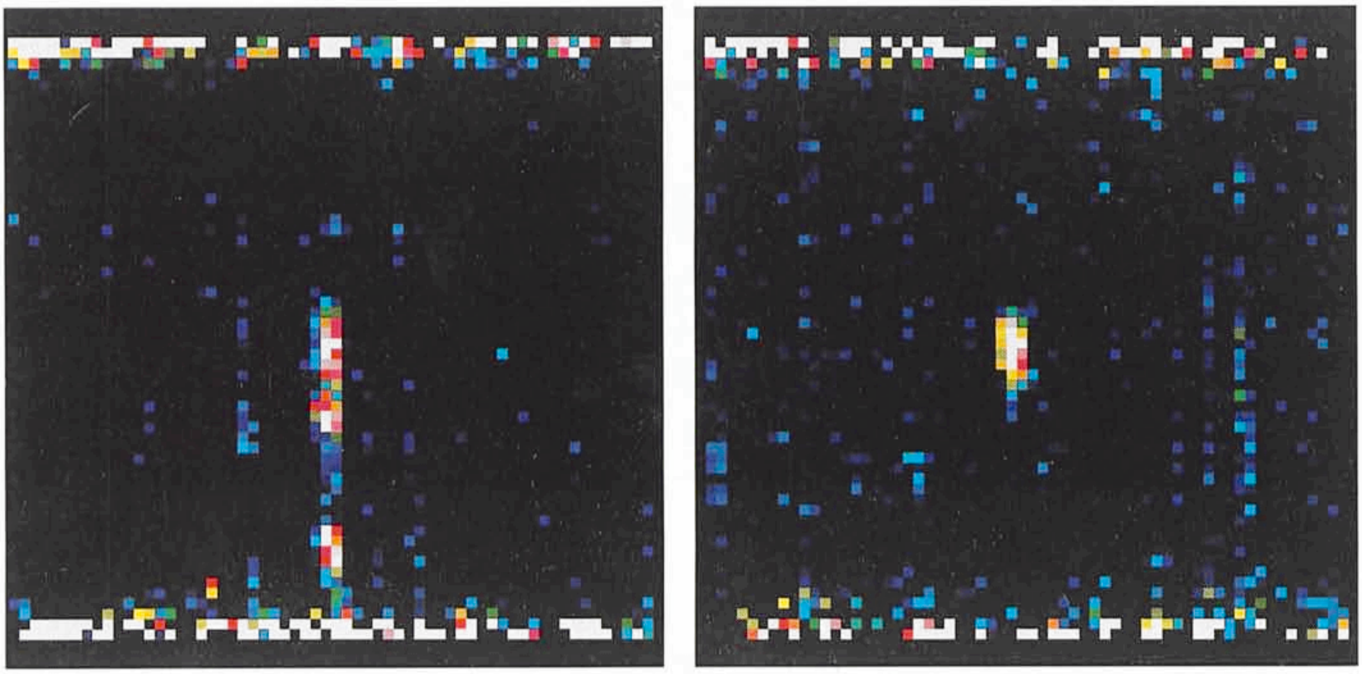

Figure 3: *Sky-subtracted frames of the HH 111 jet in [Fe II] 1.644 μm (left panel) and H_2 2.121 μm (right panel). Wavelengths are in X and the slit is in Y direction. The slit is oriented along the jet axis. The on-source integration times are 5×60 s. The white horizontal pattern at the extremes of the slit are introduced by the flat-fielding and mark the region that is vignetted.*

wards the low-excitation Herbig-Haro (HH) object HH 91A. HH 91A is a bright knot in the HH complex HH 90/91 in Orion (Gredel et al. 1992). The spectra are dominated by emission lines of molecular hydrogen that arise from the electric quadrupole cascade in the $X^1\Sigma_g^+$ groundstate of H_2. Individual lines are identified in the spectra. The spectrum shown in Figure 2 consists of 16 individual segments, each obtained with an integration time of 4×1 min on the object and a similar time on a reference position. The resolution is $\lambda/\Delta\lambda = 2500$. The inferred population densities of the H_2 levels follow a thermal distribution which is characterized by an excitation temperature of 2750 K. It is believed that the emission lines seen in HH objects arise from the recombination region behind a shock. The excitation temperature measured in HH 91A indicate shock velocities of a few tens of km/s. Non-thermal excitations of H_2 levels which can be introduced by UV photons that are expected to arise in the apex of strong bow-shocks are not observed in HH 91A. The reddening towards HH 91A can be determined from a comparison of the intensities in the (1,0) S(1) and the (1,0) Q(3) lines which arise from a common upper level. A value of $E_{B-V} \leq 0.6$ mag is found.

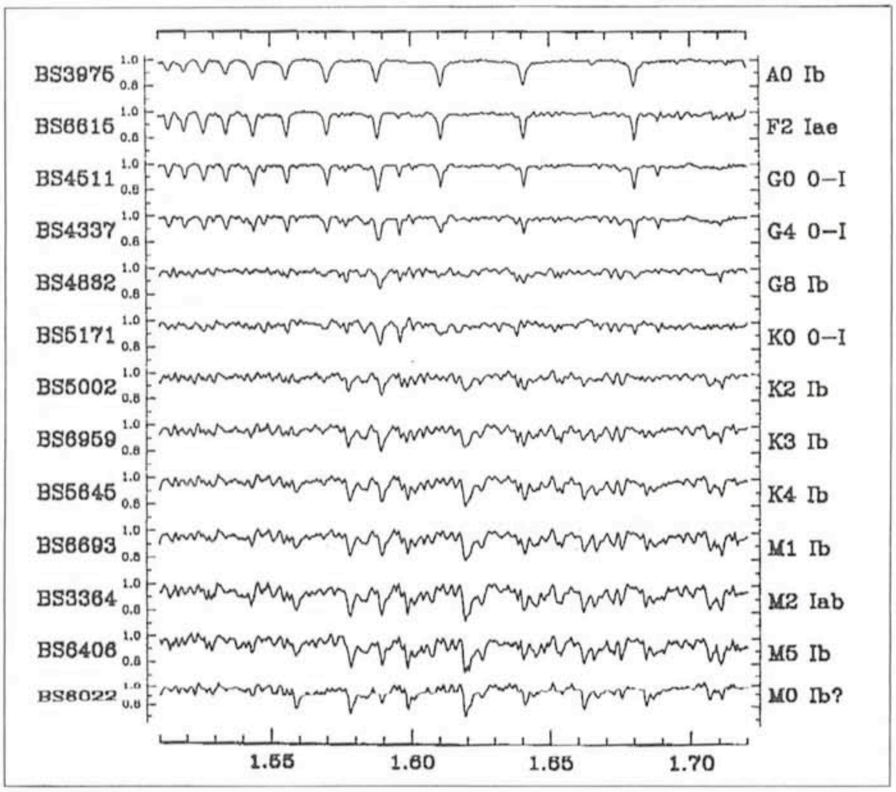

Figure 4: *H band spectra of supergiant stars.*

HH 111. Figure 3 shows two IRSPEC frames in [Fe II] (1.644 μm) and H_2 (2.121 μm) obtained towards the well collimated HH jet HH 111. The frames are sky-subtracted and flat-fielded using an internal halogen lamp. A tilt of the spectral lines in the raw frames, introduced by the off-axis Littrow mount of the grating, has been removed by shifting each row appropriately. The enhanced background that can be seen in the upper and lower part in both frames results from the flat-fielding and marks the parts of the slit that are vignetted. The slit is in Y direction and has a scale of 2.2″ per pixel. It is aligned along the HH 111 jet and centred on knot H (see e.g. Reipurth 1991). The H_2 frame shows three emission maxima along the jet and follows the intensity distribution of Hα, as inferred from a CCD frame obtained at the Danish 1.5-m telescope. The three maxima seen in the H_2 frame correspond to knots D-H, knot L, and knot P (Reipurth 1991). [Fe II], on the other

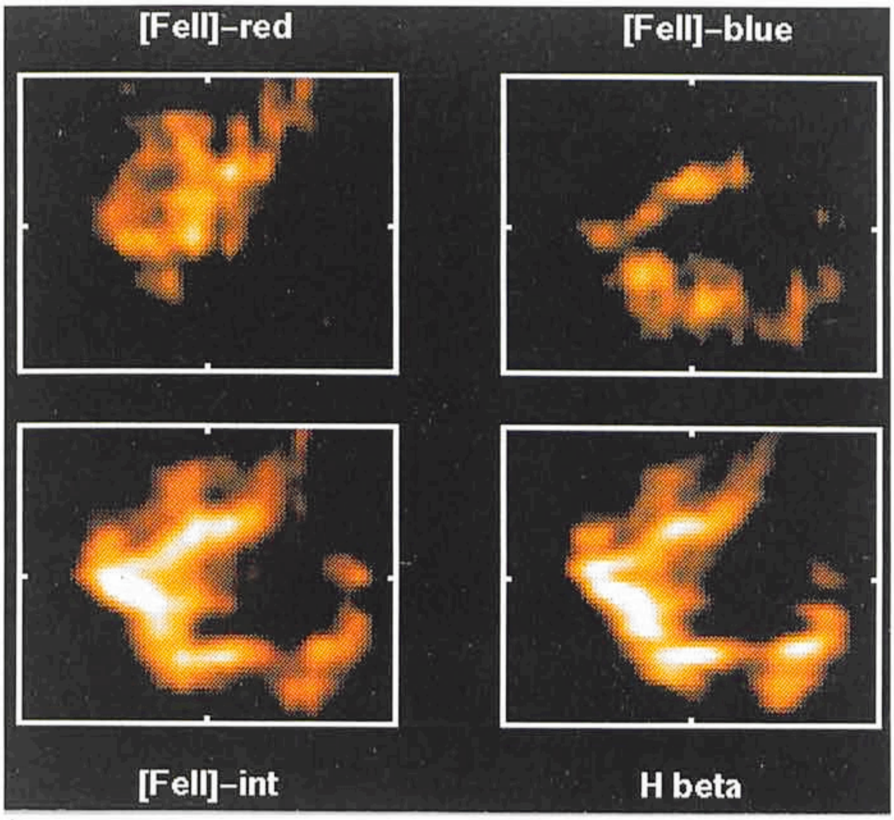

Figure 5: *Images of the LMC supernova remnant N 49 in the [Fe II] (1.644 μm) line obtained by slit scanning. The field is approximately 1′ with N at the top and E to the left. The upper panels show images in velocity bands 200 km/s wide. The lower [Fe II] image is integrated over all velocities. It has the same cut levels as the Hβ interference frame shown in the lower right.*

side, has a significantly different distribution. In particular, the [Fe II] emission is strong near knots D-H, whereas it is weak around knots L and P.

Giants/Supergiants. The high resolution of IRSPEC has initiated a spectral classification programme of giant and supergiant stars (Origlia et al. 1992). Figure 4 shows spectra of A-M supergiant stars between 1.51 μm and 1.72 μm. The spectra of the hottest stars with A-G spectral types are dominated by Brackett series hydrogen absorption lines. The cooler stars show a variety of molecular and atomic absorption bands whose equivalent widths increase towards later spectral types. Note that the reproducibility of the faintest spectral features indicates that the noise in these spectra is comparable to or less than the thickness of the traces.

N 49. IRSPEC can be used to obtain spectral line images of extended objects. An example is shown in Figure 5 which contains [Fe II] images of the supernova remnant N 49 in LMC. The images are reconstructed from individual IRSPEC frames, obtained by scanning the slit across the object. The red and blue [Fe II] images, shown in the upper part, contain the emission integrated in 200 km/s wide bands, centred 270 km/s to the red and blue of the systemic velocity. They reveal an interesting velocity structure which suggests that the northern and southern filaments are probably located on opposite sides of an expanding shell. In the lower part of Figure 5, the [Fe II] image, obtained by integrating over all velocities, is compared to an Hβ interference filter image obtained with the CCD camera at the 2.2-m telescope. The latter frame has been smoothed to the same spatial resolution (≈ 2″) as the IRSPEC image. Both images have the same cut levels, and show that the morphology and the

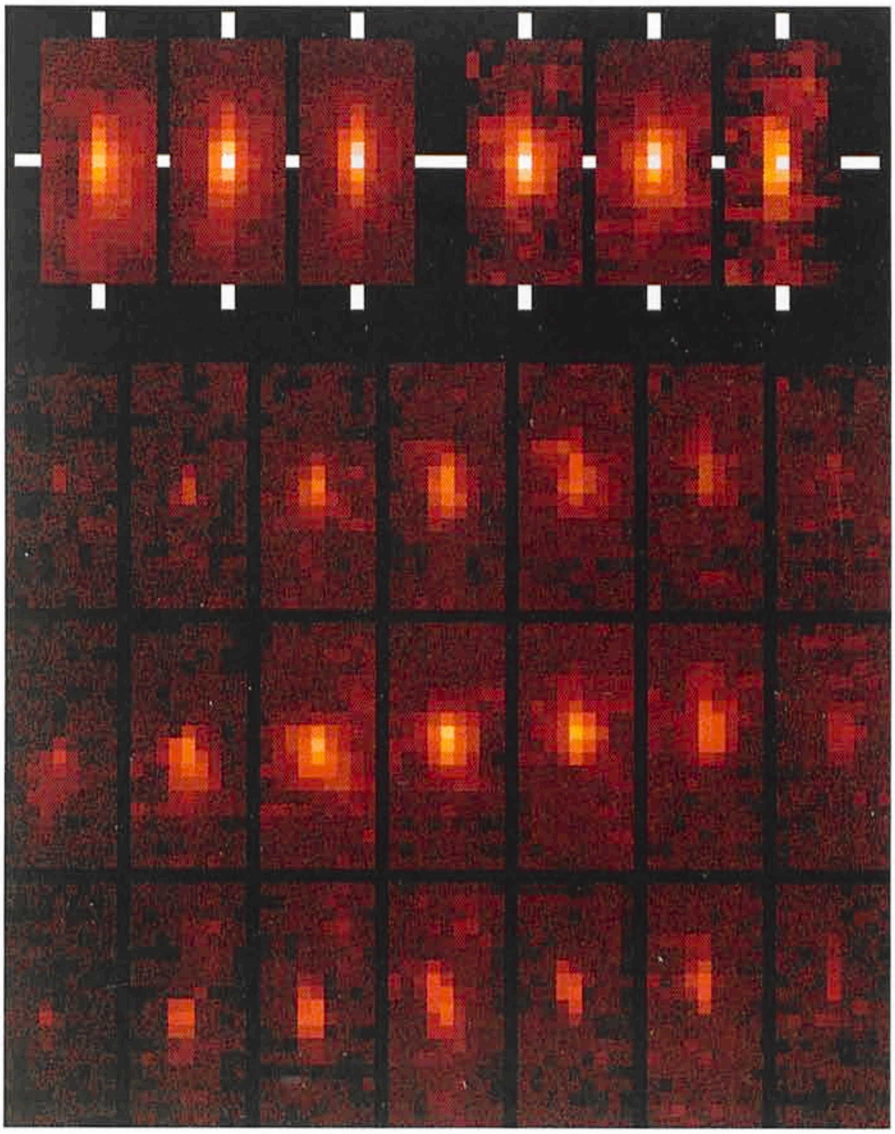

Figure 6: *Images of the nearly edge-on late type spiral galaxy NGC 4945 obtained by stepping the IRSPEC slit. The upper row shows the continuum image (three frames to the left) and the corresponding emission in [Fe II] (1.644 μm), H_2 (2.121 μm) and Brγ (2.167 μm) (three frames to the right). The second, third and fourth rows show seven images in each of these three lines, in steps of 1 pixel, i.e. at increasing velocity, from left to right.*

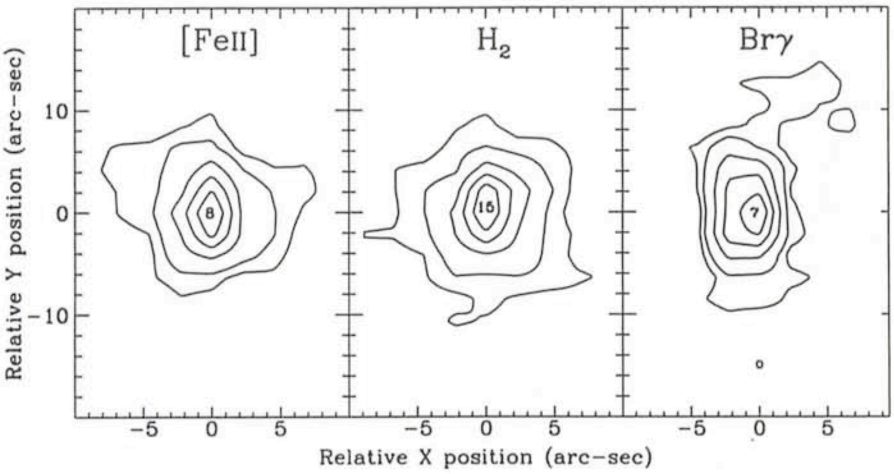

Figure 7: *Contour maps of NGC 4945 in [Fe II], H_2, and Brγ.*

surface brightness seen in [Fe II] and Hβ are remarkably similar.

NGC 4945. Figure 6 contains images of the nearly edge-on late type spiral NGC 4945, obtained by stepping the IRSPEC slit. The upper six panels show emission in the continuum (left) and [Fe II], H_2 and Brackett γ lines (right) at 1.644 μm, 2.121 μm and 2.167 μm, respectively. The lower panels show images in the same lines but in velocity slices separated by 1 pixel or 97 km/s for [Fe II] and 66 km/s for the other two lines. The dynamics is dominated by a velocity gradient of 15 km/s/arcsec. This is the same as that obtained from millimetre CO observations which reveal the presence of a molecular disk or torus in which the infrared line emitting region is embedded (Moorwood and Oliva 1992).

Figure 7 contains the contour maps of NGC 4945 in the [Fe II], H_2 and Brγ lines. The emission in all three lines extends ≈ 650 pc along the major axis which is parallel to the Y axis in this figure. Of most interest, however, is the similarity of the [Fe II] and H_2 distributions and the fact that they are more extended than the Brγ emission along the minor axis. Taking into account also the integrated line luminosities and ratios it appears most likely that the Brγ emission arises in gas photoionized by hot stars in a nuclear starburst while the [Fe II] and H_2 lines are shock excited by a supernova driven superwind (Moorwood and Oliva 1992).

NGC 1068. Figure 8 contains complete J, H and K band spectra of the Seyfert galaxy NGC 1068 showing a wide range of identified spectral features and some whose origin is still unclear. More than 50 grating settings were required. The integration time per setting was 60 s. Of particular interest are the strong and broad [Si VI] (1.96 μm) (blended with narrow H_2 (1,0) S(3) emission) and [Si VII] (2.48 μm) coronal lines and the wealth of stellar absorption features in the H band (Moorwood and Oliva 1992).

PKS 0237-23. The high sensitivity of IRSPEC allows the study of quasars in the near infrared. Studies in the UV and optical wavelength region have revealed the presence of different classes of sharp line absorption systems at redshifts lower than that of the quasars. Among those are metal-line systems believed to arise in H II regions in gas-rich and star-forming intervening dwarf galaxies. This hypothesis can be tested by searching for Hα lines at redshifts smaller than that of the quasar, and other unequivocal signatures of an H II

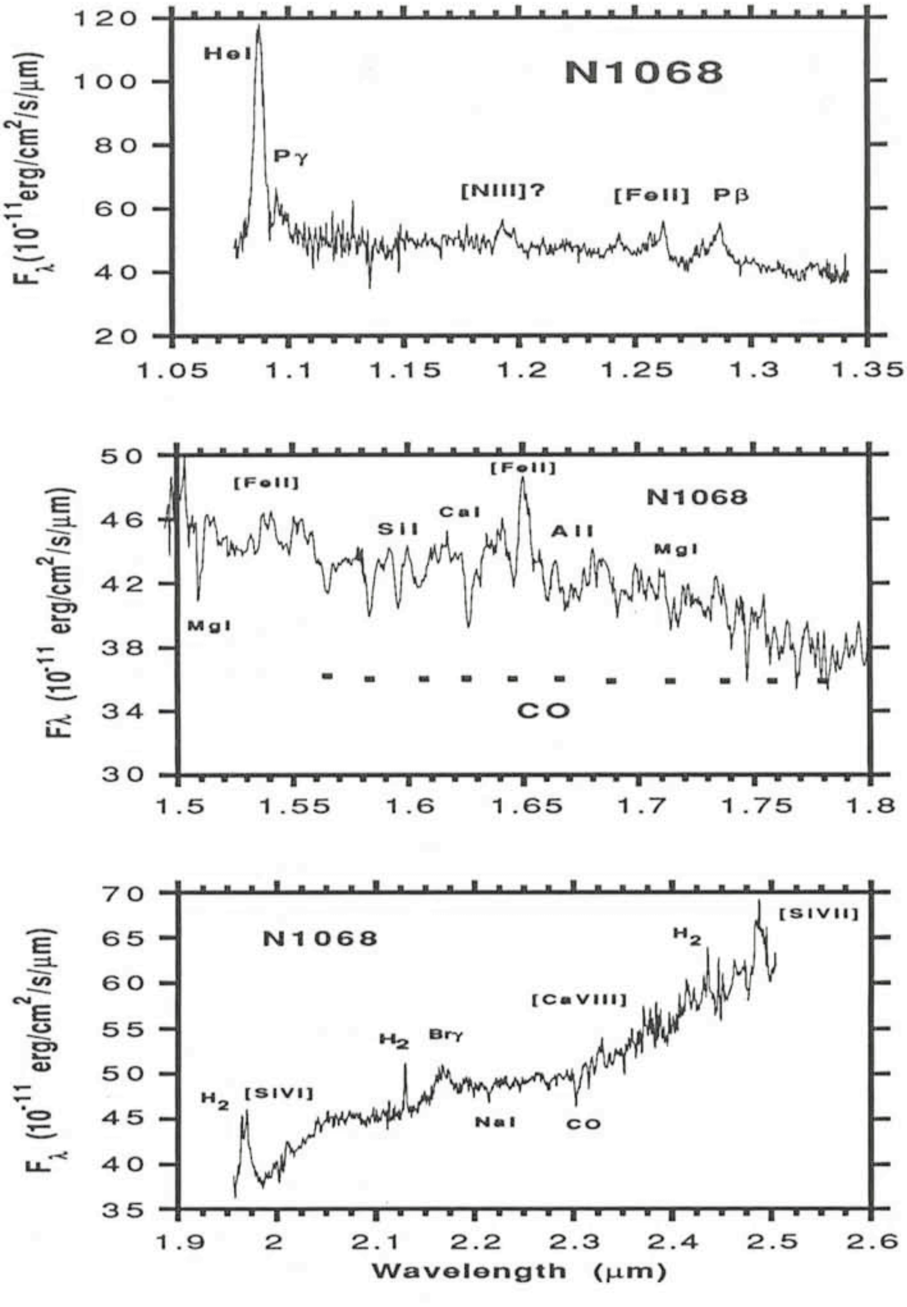

Figure 8: *Complete J, H and K band spectra of the Seyfert galaxy NGC 1068. Individual spectral features are identified.*

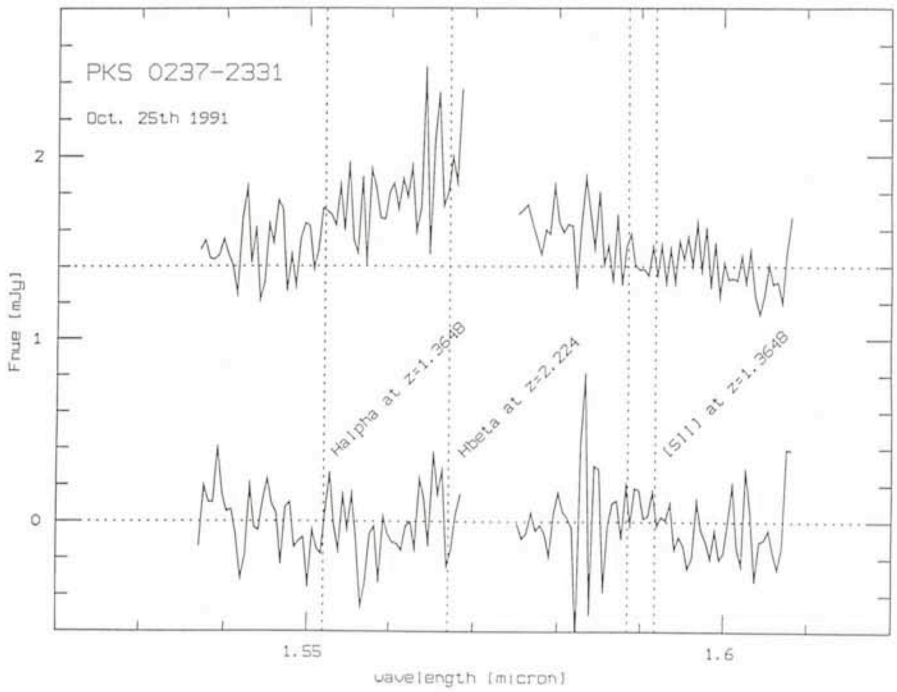

Figure 9: *Spectrum of Hβ at a redshift of z = 2.224 towards the quasar PKS 0237-23 (upper spectrum) and a reference sky position (lower spectrum). The horizontal dotted line in the upper spectrum marks the quasar continuum. The vertical lines show the location of Hα and [S II] at z = 1.3648. The centre of the Hβ line at z = 2.224 is indicated.*

region. Because the redshifts are, in general, larger than one, many of these transitions are shifted into the infrared domain. Figure 9 contains the spectrum between 1.54 μm and 1.61 μm towards the quasar PKS 0237-23 (Käufl et al. 1992) which has a redshift of z = 2.224. The lower part contains the spectrum of a reference position for comparison. The observations were aimed to detect Hα in emission and the [S II] doublet at z = 1.3648, which corresponds to the redshift of previously reported UV absorption lines. The total integration time is 16,000 s. Hα emission is not seen at z = 1.3648. The upper limit in the Hα luminosity of 2.5×10^{42} erg s^{-1} indicates that the star-formation rate in the intervening system is 22–36 $M_{\odot}$/yr at most. The continuum of the quasar in H is 1.4 ± 0.2 mJy. The Hβ line is detected at the redshift of the quasar, however. The gap in the spectrum right at the peak of Hβ reflects the serendipitous character of the observation. The line width is 4000 km/s and agrees with that of Hα, earlier detected in PKS 0237-23.

Acknowledgements

It is a pleasure to thank H.U. Käufl, A. Moorwood, E. Oliva, and L. Origlia for providing some of their unpublished results, and E. Oliva for making available his MIDAS routines to correct for the spectral line tilt.

References

Gredel, R., Reipurth, B., and Heathcote, S.: 1992, *A&A*, in press.
Käufl, H.U., Rosa, M., Caulet, A., and Viegas, S.M.: 1992, submitted to *A&A*.
Moorwood, A.F.M., and Oliva, E.: 1992, to appear in *PASP Proceedings of Calgary Infrared Spectroscopy Conference*.
Moorwood, A.F.M. and Oliva, E.: 1992, in preparation.
Origlia, L., Oliva, E., and Moorwood, A.F.M. 1992, *A&A*, submitted.
Reipurth, B. 1991, *Nature* **340**, 42.

TIMMI at the 3.6-m Telescope

H. U. KÄUFL, ESO
R. JOUAN, P. O. LAGAGE, P. MASSE, P. MESTREAU, A. TARRIUS, DAPNIA/SAP, CEN-Saclay, France

Careful readers of *The Messenger* may have stumbled over the acronym TIMMI occurring in the context of instrumentation in various previous issues (see e.g. No. **61**, p. 58). In this article we report about the first commissioning run on La Silla in July 1992 and give a short description of the instrument. TIMMI stands for Thermal Infrared Multimode Instrument. TIMMI is supposed to become a general user instrument allowing for imaging as well as limited long-slit spectroscopy in the 10-μm atmospheric window. The project started in July 1990 when ESO signed a contract with the Service d'Astrophysique of the Commissariat à l'Energie Atomique for the development and supply of TIMMI (Principal Investigator: P. O. Lagage). The instrument was then built by the SAP according to ESO's specification in a period of two years.

1. Description of TIMMI

Like all infrared instrumentation TIMMI is a cryogenic instrument. It is mounted inside a Solid Nitrogen/Liquid Helium cryostat. Its optical principle is best described as an "infrared EFOSC". The optics consists of a f = 136-mm lens having a triple function: entrance window to the Dewar, focal reduction and field lensing. The telescope focal plane is located inside of the Dewar. Behind a f = 103-mm collimator there is a 3.6-mm ∅ pupil stop. The filterwheel is located behind that pupil stop in the collimated beam. This is followed by a lens-wheel.

The camera has three mechanical functions (operated remotely under computer control): a mechanism to exchange the cryogenic field mask with a cryogenic slit assembly, a filterwheel and a lenswheel. Figure 1 shows the non-trivial parts of the camera disassembled. The camera is interfaced to the telescope with the standard infrared adaptor (see Fig. 2) and utilizes the f/35 chopping secondary unit. It can be mounted both at the 3.6- and 2.2-m telescopes. At present, however, operation is foreseen primarily at the 3.6-m telescope.

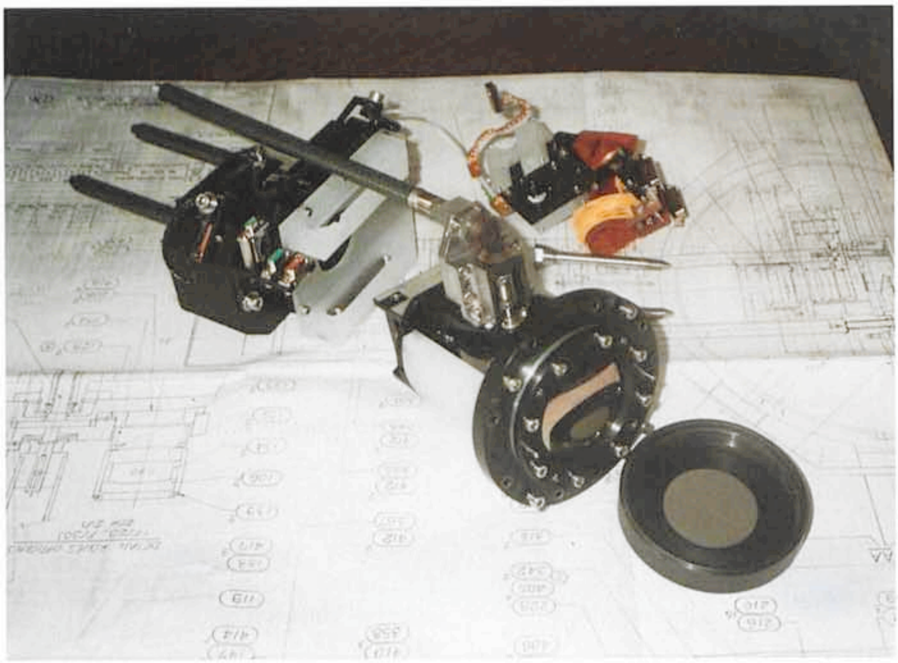

Figure 1: *The rare but essential ingredients of the camera cryostat are shown: cryostat entrance lens with mounting flange and slit assembly (front centre), block containing the lens wheel and the filter wheel (behind, left) and detector assembly with flexible cable (behind, right). The diameter of the flange holding the entrance window is 120 mm. All optics is from Germanium. Slit assembly and collimator are cooled to ≤ 75 K, lens and filter wheel to ≤ 60 K. The detector is connected directly to the liquid Helium bath. The greyish cylinders protruding into the upper left corner are the actuator rods connected to 4-phase stepper motors outside of the cryostat.*

The camera features a 64×64 element Gallium doped Silicon array bonded to a silicon Direct Voltage Readout (DVR) circuit. This detector has been manufactured by Leti/LIR, Centre d'Etudes Nucléaires de Grenoble, France. It has a well capacity of $\approx 2 \cdot 10^7 e^-$. The cut-Off wavelength of the detector material is ≈ 17.8 μm. Various magnifications can be chosen (at present 0.3 arcsec/pix, 0.46 arcsec/pix and 0.6 arcsec/pix). On the filterwheel a variety of standard filters as well as sufficient spare positions are available for specialized filters. The filters are mounted in a collimated beam so that no or only very limited refocussing of the instrument is required after change of the filter. Also the lenses are well enough pre-adjusted that no appreciable focus-shift occurs after the change of magnifications.

Because of the strong background radiation emitted by atmosphere and telescope in this part of the spectrum, rapid readout of the detector as well as fast processing of the data is required. Therefore TIMMI has an electronic front-end system somewhat faster but otherwise very similar to the ones already in use with the other infrared instruments

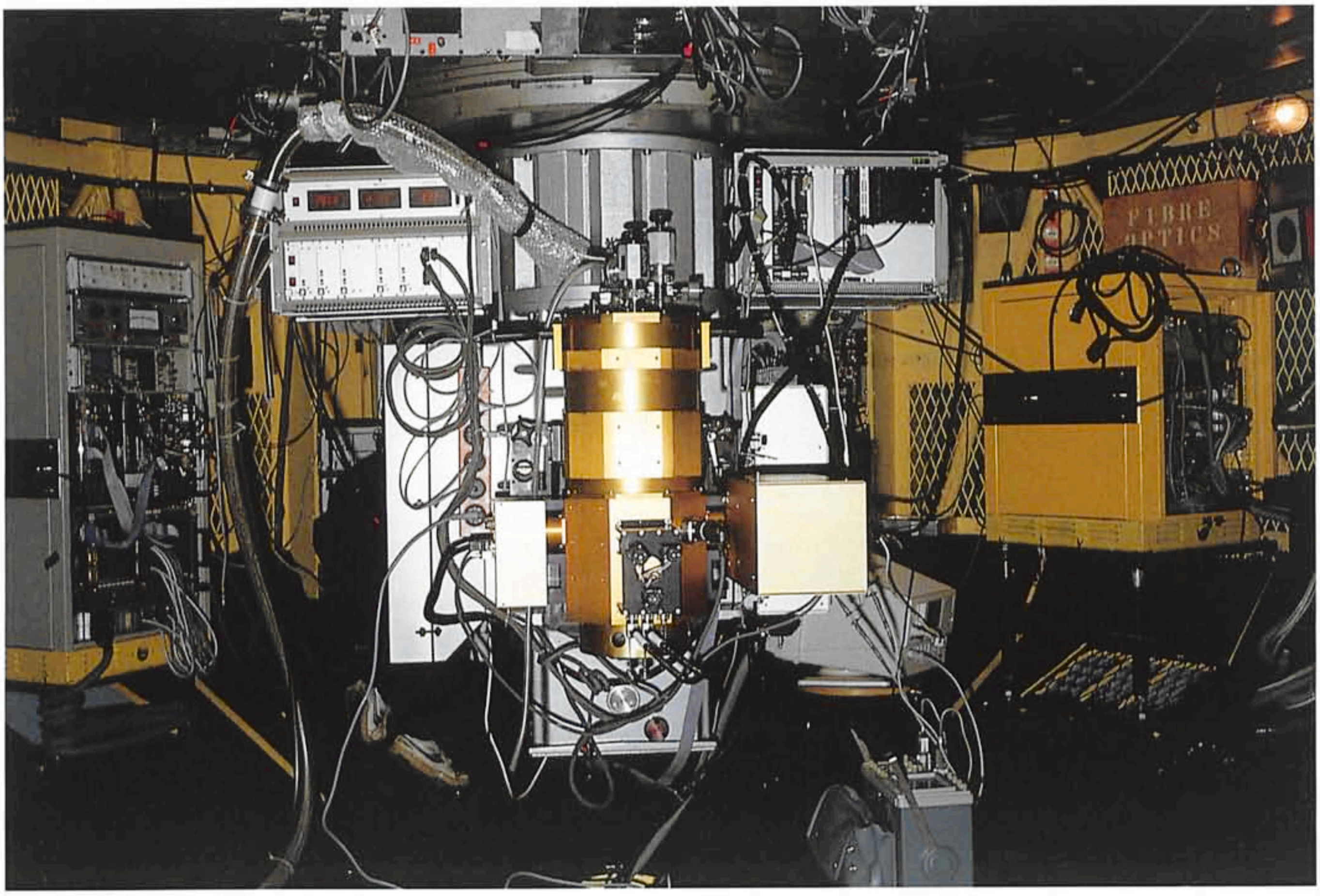

Figure 2: *This shows the complete cryostat of TIMMI mounted on the f/35 adaptor unit in the Cassegrain cage of the 3.6-m telescope. The entire camera/spectrometer is contained in a 30-cm diameter cryostat. In the lower centre of the cryostat the three stepper motor drives are easily distinguishable. On the top right of the adaptor flange the VME-rack with the preprocessing unit can be seen.*

(IRSPEC, IRAC1 and IRAC2) on La Silla. The frontend allows to read out the detector array in ≈ 7 ms and processing of the results according to the requirements of synchronous detection.

While TIMMI will provide new observational possibilities for the ESO users community it is also supposed to become a test-bed to gain experience for similar instrumentation at the VLT.

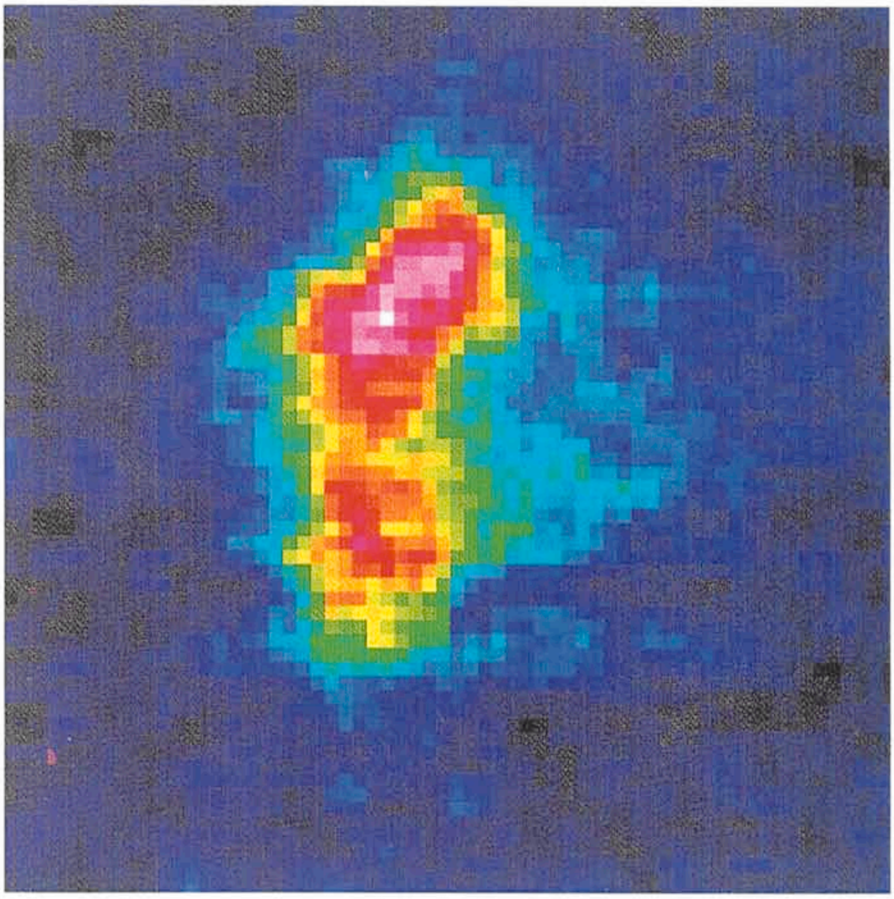

Figure 3: *This is an image of the Planetary Nebula NGC 7009 through a narrow-band filter centred at the wavelength of the 10.52-μm line of triple ionized Sulfur (ionization potential 47.3 eV). South is up on this image, east to the right. The pixel scale is 0.46 arcsec/pix, i.e. the size of the frame is ≈ 30×30 arcsec^2. The location of the central star would be right on the centre of the array but it is too faint at this wavelength to be detected. The observation of such lines in compact Planetary Nebulae is of particular scientific interest because of the high spatial resolution (0.9 arcsec FWHM) and the fact that even very compact nebulae are optically thin at these wavelengths. The integration time for this image was 12 min.*

2. First Results

In the first test period a complete checkout of the imaging modes of the camera was possible. We could verify the image quality (typically 0.9 arcsec FWHM) which is only 30% larger than the diffraction limit of the 3.6-m telescope. The sensitivity achieved is also within the range of expectations. When observing stars close to the detection limit of IRAS with a spectral bandpass 8.0–13.3 μm, we achieved e.g. for the 1000-mJy source SAO 192176 (IRAS 23468-2153) a S/N of 5–6 σ for the brightest pixel (scale 0.3 arcsec) for 80 s integration. If one compares the flux integrated over the 5 brightest pixels to the noise then the S/N becomes 9 σ. This indicates that on point sources TIMMI will allow to go fainter than the IRAS 12-μm channel while providing for near diffraction limited image quality.

TIMMI also compares favourably with the existing bolometer. Similar measurements with the other filters having a narrower spectral bandpass have not been done yet, but it can be expected that the sensitivity will be slightly better since the detector tends to perform better if it is exposed to less background radiation. For the above-quoted observation the background signal was $5 \cdot 10^5$ ADU per second and pixel, while the signal from the star was 110 ADU/s in the brightest pixel. All observing was done in chopping and nodding mode (≈ 6.3 Hz, amplitude 7–30 arcsec). As compared to nodding every 30s alone chopping increased the sensitivity typically 8–10 fold.

In Figure 3 we show how the instrument operates with a narrow-band filter. This image was made using a 2%-bandpass centred around the wavelength (10.52 μm) of the forbidden transition of S IV. Similar filters are available for Ar III And Ne II. The Ne II filter was successfully used to image the low excitation Planetary Nebula IC 418.

Table of Filters of TIMMI:

M-band filter	λ_{centre}:04.71 μm	$\Delta\lambda$:0.63 μm
N-band filter	λ_{centre}:10.10 μm	$\Delta\lambda$:5.10 μm
N$_1$ filter	λ_{centre}:08.39 μm	$\Delta\lambda$:0.96 μm
N$_2$ filter	λ_{centre}:09.78 μm	$\Delta\lambda$:1.29 μm
N$_3$ filter	λ_{centre}:12.56 μm	$\Delta\lambda$:1.41 μm
ArIII	λ_{centre}:08.99 μm	$\Delta\lambda$:0.19 μm
SIV	λ_{centre}:10.52 μm	$\Delta\lambda$:0.23 μm
NeII	λ_{centre}:12.78 μm	$\Delta\lambda$:0.25 μm
Q-band	λ_{centre}:17.15 μm	$\Delta\lambda$:1.50 μm
...	λ_{centre}:11.65 μm	$\Delta\lambda$:2.70 μm
...	λ_{centre}:09.70 μm	$\Delta\lambda$:0.49 μm
...	λ_{centre}:11.30 μm	$\Delta\lambda$:0.57 μm
...	λ_{centre}:08.60 μm	$\Delta\lambda$:0.40 μm
...	λ_{centre}:07.70 μm	$\Delta\lambda$:0.35 μm

N.B.: The exact position of these filters may be slightly different because they still need to be exactly measured when mounted in the camera under operating conditions.

3. Future Work and Use of TIMMI by the Community

As stated above, TIMMI should also work as a moderate-resolution spectrometer. This mode could not yet be implemented, however, because ESO has not been able to procure suitable grisms (transmission gratings mounted to the back of prisms). Even though ESO had a prototype device on loan for evaluation from a commercial source, all attempts for procurement failed even though an intensive market survey was made. ESO therefore concluded a contract with the Fraunhofer Gesellschaft (Institut für Festkörpertechnologie, München) to produce such gratings from monocrystalline Germanium wafers. These gratings will then be packaged together with prisms and mounted to the filter wheel of TIMMI. We expect to receive the first test structures by the end of this year, while the complete set of grisms may be available in summer 1993. TIMMI will then provide a long-slit spectroscopic mode with a resolution $\lambda/\Delta\lambda \approx 300$ for a slit length of ≈ 35 arcsec.

As for the other IR systems on La Silla the preprocessor is a selfcontained hardware/software unit which also provides for a reasonable quick-look facility. Nevertheless, data transfer and data storage including more sophisticated on-line analysis of the raw data are required and have to be prepared. Right now TIMMI is operated from a MicroVAX which is made available on loan to ESO from the SAP for the observing runs. But even now all data can be easily transferred (via magnetic mass storage) to MIDAS for off-line analysis.

For operation at longer wavelengths (16.4 to 17.9 μm), a specialized lens is under construction which will be incorporated into the camera. This lens will be a doublet of CdTe with a pixel-scale of 0.45 arcsec/pix. A special antireflection coating will ensure that this mode will be $\approx$ 10 times more efficient as compared to using the standard Germanium camera lenses.

The next test period and a scientific observation period (the scientists of the SAP are entitled to several nights of guaranteed observing as a compensation for their effort) are scheduled for January 1993. ESO will inform the users in the announcement for observing period 52 (Oct. 1993 – March 1994) about how to apply for observing time with TIMMI.

Acknowledgements

We are grateful to all ESO staff in Garching and La Silla who supported us and thus made this first observing run successful. We would, however, like to specifically mention the help of B. Delabre, A. van Dijsseldonk, G. Fischer, M. Meyer, A. Moorwood and A. Silber in Garching and of H. Gemperlein, E. Matamoros, J. Roucher and U. Weilenmann at La Silla.

Fire at the 1-m Telescope!

During the past months, there had been much concern about how well the 1-m telescope dome is able to protect its valuable contents against the external elements. On some occasions, water was actually found in several places in the building after one of the numerous rainstorms this winter. As this might have a very adverse effect on the telescope electronics and optics, a programme to improve the water-impermeability of the dome was duly initiated.

On Sunday, October 25, asphalt had to be put on an area joining the building with the rotating dome. A torch was used in order to heat the asphalt to the appropriate temperature, but unfortunately some flames reached the inner part of the dome, which is covered by a special painting that is very inflammable. In a matter of seconds, all the inner part was on fire. An extinguisher that was ready for use was not of much help due to the great speed with which the fire progressed. The La Silla fire brigade came quickly (this was by the way the first time since its creation that its help was needed) and after a few minutes the situation was under control. Nobody was injured although the toxic gases produced inside the dome prevented people from entering without a mask for several hours.

As soon as possible, a thorough evaluation of the destruction took place. The inside cover of the dome was completely burnt. On November 10 it had already been cleaned and repainted. The cover of the floor suffered a lot, especially from drops of burning dome paint, and must be replaced. The inside crane is unusable. Hopefully, the delicate parts of the electronics and tele-

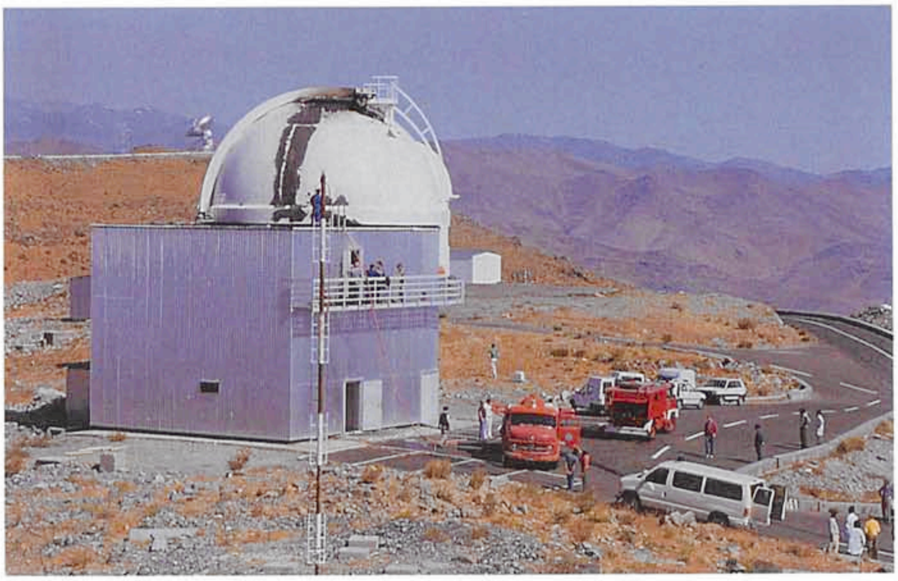

Figure 1: *The 1-metre dome after the fire on October 25, 1992. Photos by H. Barwig, München (who lost all his observing time).*

Acknowledgement

As visiting astronomers directly affected by the fire we would like to make the following remarks;

- Thanks to the quick, careful and efficient action of the ESO fire brigade, our special fiberoptic multicolour photometer (MCCP) was not severely damaged by the fire. After a lot of cleaning work and extensive tests that we were able to perform in the optical lab the next day, the instrument was once again operable.
- Shortly after the fire, the ESO staff members expressed their regret for the incident and immediately tried to obtain one or two extraordinary nights at one of the larger telescopes where our instrument could be used likewise: not an obvious gesture but one which was very welcome for us after the loss of all our observing time. Since it turned out that no test time was available, another observing run was arranged at the 1-m telescope in December.

We would like to thank all the people who made it possible for us still to perform our observations with such a short delay.

H. BARWIG, K.H. MANTEL,
Universitäts-Sternwarte München

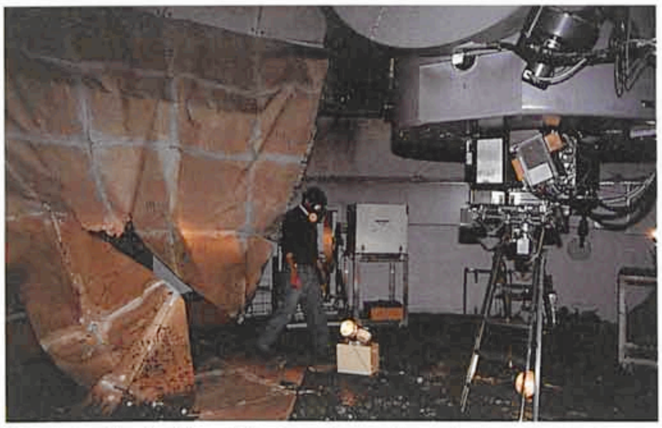

Figure 2: *The inside of the 1-m dome, just after the fire had been extinguished. The 1-m telescope and the multichannel photometer fortunately do not seem to have suffered bad damage. This was later confirmed.*

Figure 3: *On the next day, the cleaning work began. Thanks to a very dedicated effort by ESO staff, this only lasted two weeks and the telescope was again in operation by mid-November.*

scope control system suffered no major damage. The mirrors had to be cleaned; the secondary was realuminized, while it is not necessary to realuminize the primary immediately.

The image quality fortunately did not suffer from this bad experience, as shown by an Antares run conducted on November 6. The instruments on the telescope – a special photometer just installed when the fire started – did not suffer much, although it obviously had to be cleaned very thoroughly.

The La Silla operations and mechanics and construction groups made a tremendous effort to quickly return the telescope to the astronomical community. The normal schedule of observations started again on November 12, following some necessary test nights. *A. SMETTE, ESO-La Silla*

Astronomical Data Handling: Windows of Opportunity and of Challenge

F. MURTAGH, ST-ECF, Garching

It is the destiny of astronomy to become the first all-digital science.[1]

1. Medium and Message

The different sections of this article start up a few windows, in order to view some current developments affecting astronomical storage and retrieval. As an area driven powerfully by collective research efforts, we can only offer a small (but colourful!) palette of what is currently available.

Dusty card decks, screaming paper tape and (soon) cumbersome 9-track magnetic tape reels have given way to storage devices of the sort shown in Figure 1. The reel of 9-track $\frac{1}{2}$-in tape is shown for comparison.

Magnetic media include QIC, Exabyte and DAT cartridges, respectively using 6 mm, 8 mm and 4 mm tape technology.

QIC (referring to "Quarter Inch Cartridge", rather than speed) is similar to 9-track tape in capacity, but several times more compact. This streamer tape storage medium potentially suffers from heat, static build-up, and resultant positioning difficulties. Exabyte and DAT are helical-scan (hence storage-efficient) tape devices. The former is marketed uniquely by Exabyte. Unit costs for these storage media are uniformly low.

Optical media are laser-read and hence less susceptible to mishaps like head-crashes. They also are unhindered in backspacing. Periodic head realignment may however be necessary. Here we will comment on compact disks, optical disks both read-only and read-writable, and optical tapes.

CD-ROMs ("Compact Disks – Read-Only-Memory") are of somewhat better quality than their audio (music) siblings. They are being increasingly used for storage of astronomical catalogues (somewhat disingenuously referred to as "dead data"). The 12-in diameter optical disk shown in Figure 1 is of the sort used for receipt of Hubble Space Telescope archive data in Europe. The storage supported by CD-ROMs is soon to be 4 GB. And what of the near future? We will see widespread usage of erasable, or read-write, optical disks, using magneto-optic (MO) technology. These will, inter alia, come in $3\frac{1}{2}$-in diameter sizes, will cater for 128 MB, and will be attachable to anyone's laptop or notebook. For larger-scale applications,

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[1] Larry Smarr, University of Illinois, quoted in *The Economist*, October 17, 1992.

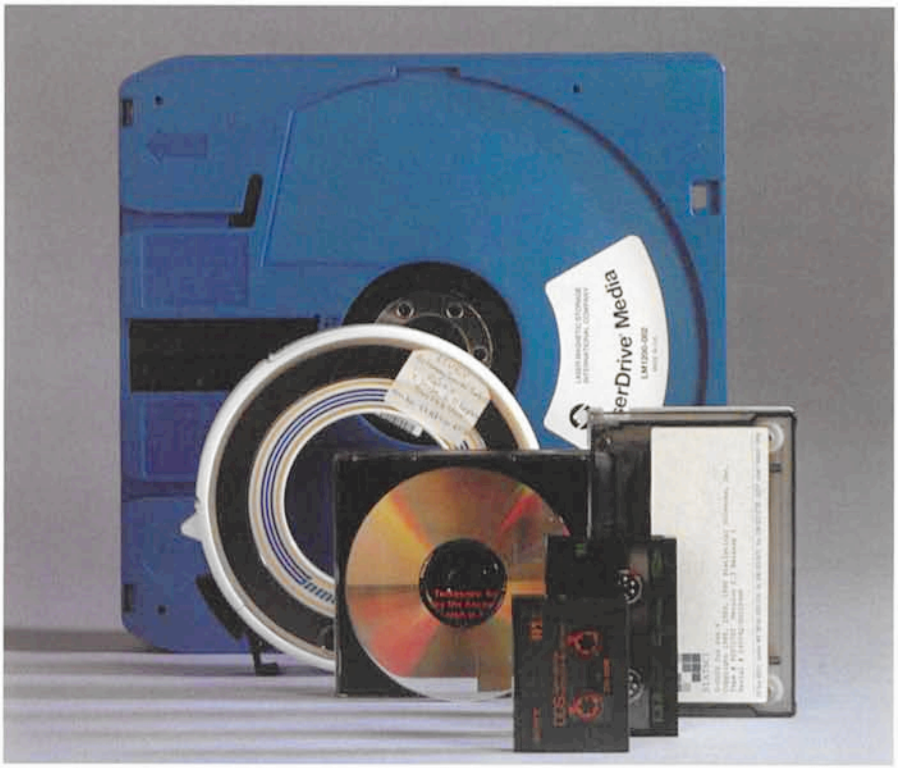


Figure 1: *Optical disk; 9-track tape (for comparison); CD-ROM; QIC; Exabyte; DAT (front).*

optical tape will allow for storage of 1 TB. Juke-boxes, to expedite the mounting and unmounting of storage devices, are still very expensive.

The examples of storage media discussed here refer to a very small range of what is available in the market-place. When it comes to the transfer of data, one should keep computer network in the pictures also. Finally, as the storage standard in common use, FITS ("Flexible Image Transport System") has imposed itself everywhere – an indication of unequivocal success.

2. Beyond WYSIWYG: What You See Is What You Want

A powerful impulse to changing the way we interface with machines was the introduction of the Macintosh by Apple in 1984. Its windows, icons and pull-down menus launched a thousand graphical user interfaces.

Support for multitasking and support of graphics are among the machine qualities that we now take for granted. The X Window System arose out of MIT's Project Athena, a joint project between MIT, DEC and IBM which began in May 1983. The current version of X, X11, has become the most widely-used windowing system on scientific workstations. *Motif* is one among many interface systems which have been built on top of X.

More basic prompt and menu-driven user interfaces are still widely used. For example, one can access the NSSDC On-Line Data & Information Service at Goddard by telneting to *nssdca. gsfc. nasa.gov* and using *nodis* as the username. But the user will generally have to wait until ordered information shows up, before accessing its relevance.

Table 1: *Indicative storage capacities and costs of drives for a range of media.*

Device	Indicative max. capacity	Indicative cost of drive
QIC	250 MB	DM 1000
DAT	2 (8) GB	DM 3000
Exabyte	2.5 (5) GB	DM 5000
CD-ROM	650 MB	DM 1000
optical disk	1.2 or 3.2 GB	DM 50000
optical tape	1 TB	DM 200000

Notes on Table: Indicative maximum capacity figures in parentheses are with use of compression; optical disk figures are for one-sided use, for different vendors. 1 MB is 1×10^6 bytes (a character or a number), 1 GB is 1×10^9 bytes, and 1 TB is 1×10^{12} bytes).

Quick-look capability introduces the same sort of inestimable improvement into working with databases as interactive computing brought to the world of batch computing. Images can be quite large (e.g. around 10 megabytes for some HST images), thereby slowing down any quick-look implementation. The clever scheme implemented in STARCAT is based on a compressed version of the image. Wavelet-based compression is one approach which has proved very effective. If loss of information is acceptable as is the case for quick-look information, then $\frac{1}{20}$th of the original image's size may suffice for an acceptable visual interpretation. The slimmed-down, but faithful, representation of the image lets the user know in real time if the image is worth retrieving or not. Figure 2 shows an example of the use of the STARCAT preview facility. Whether used for spectra or 2-d images, the potential savings in time and effort on the part of the user can be enormous.

3. United Colours of Astronomy

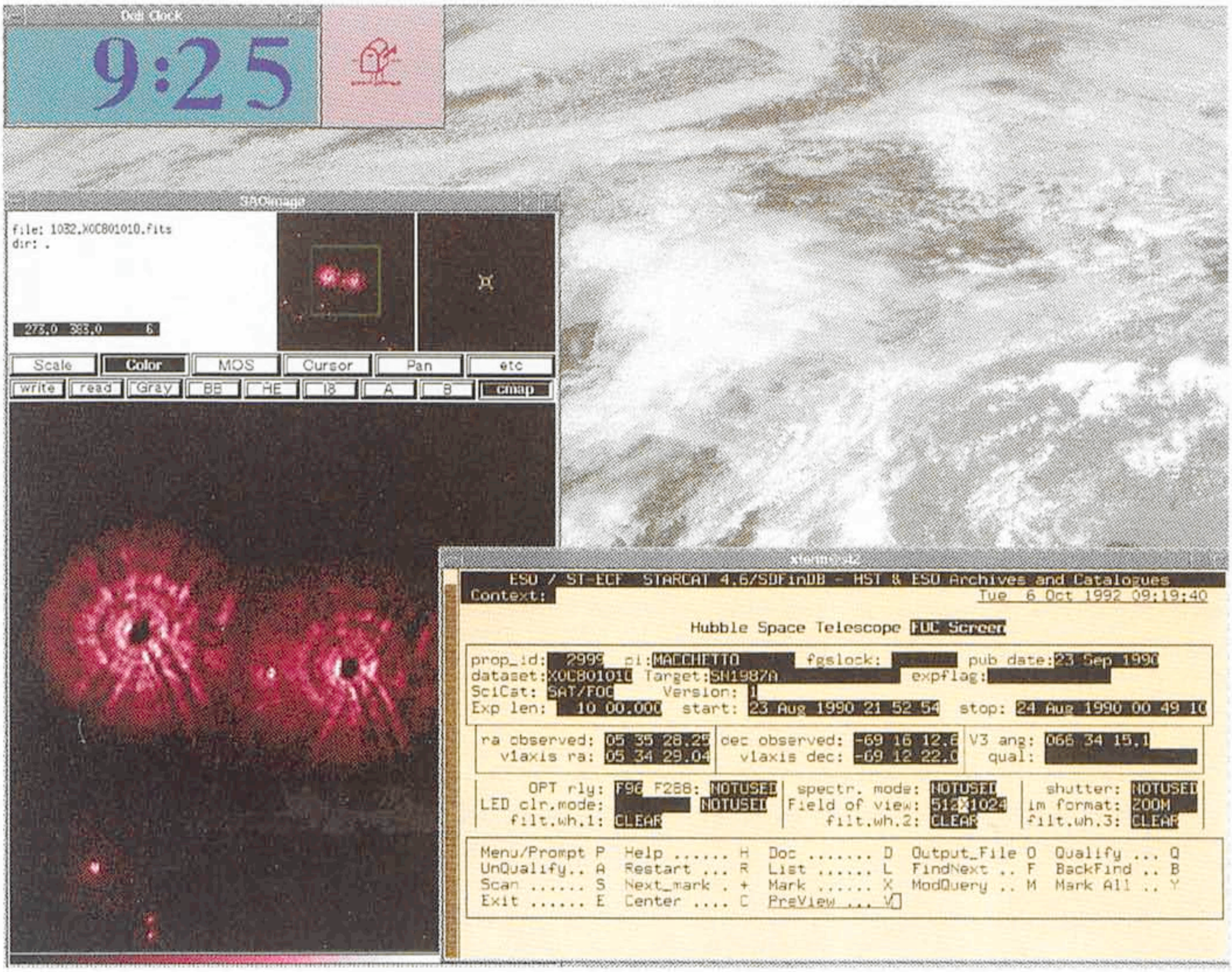
Panchromatic or pluri-disciplinary astronomy implies the use of various wavelength windows and of the results of various observational instruments. It comes at a price. Diverse data collections can occasion ambiguity, confusion and error. Among pitfalls are: physical location of data, and access procedures; nomenclature and content-characterization; homogeneity and reliability; and so on. The user must first identify what catalogues or databases are relevant; secondly, appropriate access conventions must be availed of; and thirdly, special analysis utilities may be required in order to combine different data.

The latter aspect may involve graphical approaches – image overlays and mosaics, for example; or regression or other data summarizing methods using data values affected by various errors or censoring; or model-driven data fusion such as is practised in multiframe image restoration.

Support for some of these options is becoming possible with the ESIS ("European Space Information System") Correlation Environment (CE). Figure 3 shows a summary statement of what is available on an object, across various databases. A bibliographic survey (using SIMBAD) is also illustrated.

Beyond this, the CE is ambitiously designed to be an evolving collection of display and manipulation tools. The CE is disciplined by connectivity to a query environment which is more precise and limited in its functionality.

With the CE, the "correlation of data", we are entering new and uncharted



```
 ESU / ST-ECF  STARCAT 4.6/SDFinDB - HST & ESO Archives and Catalogues
Context:                                               Tue  6 Oct 1992 09:19:40

                     Hubble Space Telescope FOC Screen

prop_id:  2999  pi:MACCHETTO        fgslock:          pub date:23 Sep 1990
dataset:X0CB01010 Target:SN1987A                expflag:
SciCat: SAT/FOC      Version: 1
Exp len:   10 00.000  start: 23 Aug 1990 21 52 54  stop: 24 Aug 1990 00 49 10

 ra observed: 05 35 28.25 dec observed: -69 16 12.6 V3 ang: 066 34 15.1
   v1axis ra: 05 34 29.04   v1axis dec: -69 12 22.0    qual:

      OPT rly: F96 F288: NOTUSED  spectr. mode: NOTUSED     shutter: NOTUSED
 LED clr.mode:          NOTUSED  Field of view: 512X1024  im format: ZOOM
    filt.wh.1: CLEAR                filt.wh.2: CLEAR     filt.wh.3: CLEAR

 Menu/Prompt P  Help ...... H  Doc ....... D  Output_File O  Qualify ... Q
 UnQualify.. A  Restart ... R  List ...... L  FindNext .. F  BackFind .. B
 Scan ...... S  Next_mark . +  Mark ...... X  ModQuery .. M  Mark All .. Y
 Exit ...... E  Center .... C  PreView ... V
```

Figure 2: *Previewing an HST Faint Object Camera image of 1987A using STARCAT.*

territory. It is, though, the type of system which is needed to channel the ever-growing flood of observational data, and to satisfy the widely-understood need that expensively-gathered data is a valuable resource for all who wish to avail of it.

4. Literature

Literature has, in time-honoured fashion, been considered a humanizing influence. How does astronomy fare in this regard? More on the point, *where* is the literature when you need it within seconds, if not sooner?

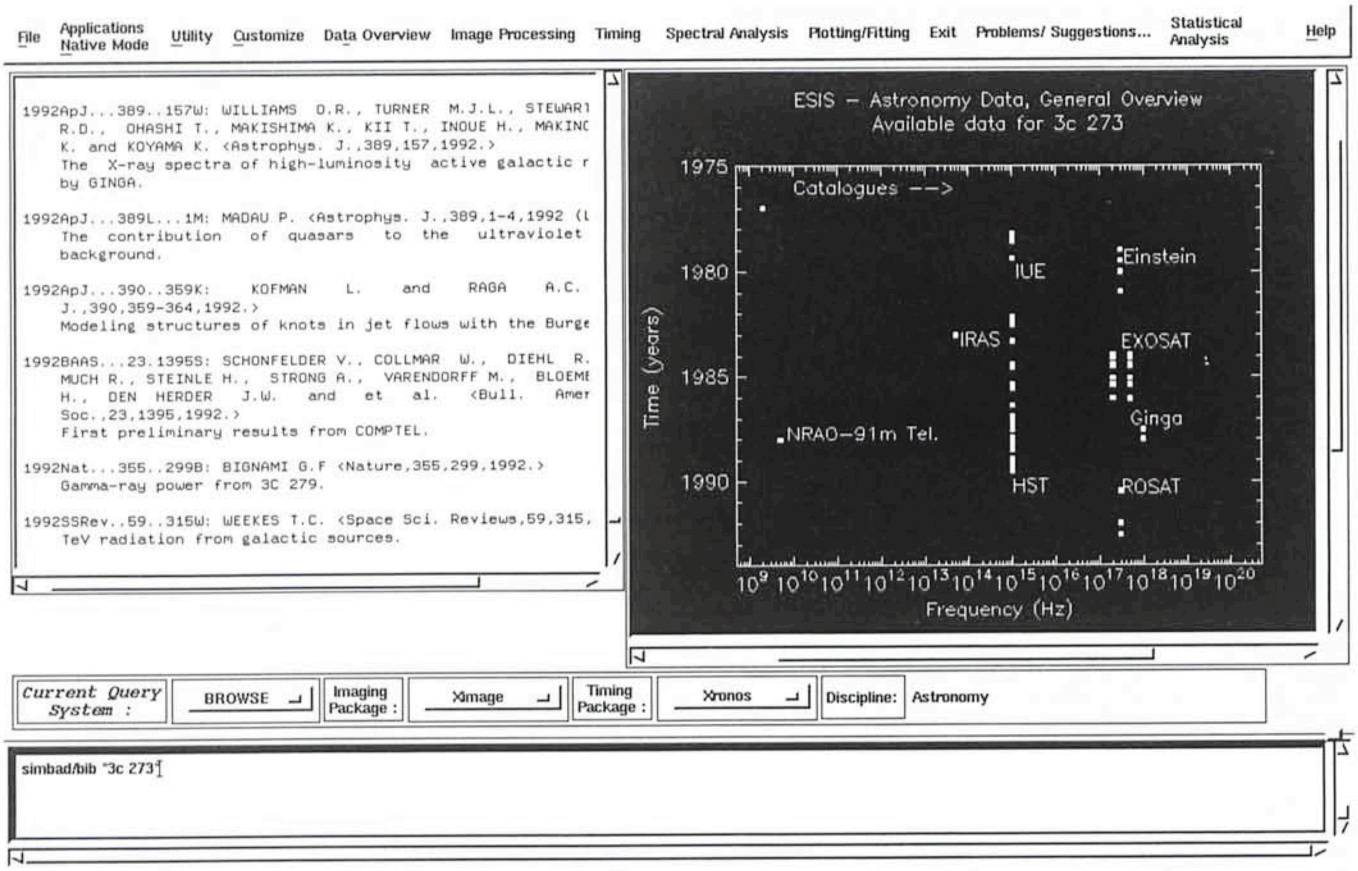
The widely-used SIMBAD database contains bibliographic references – up to 600 for an individual object. It contains approximately 1 million references in total, covering about 60,000 papers, derived from 90 astronomical periodicals.

Abstracts may be accessed through the *Astronomy and Astrophysical Abstracts* (AAA), formerly from 1899 to 1969 under the title of *Astronomischer Jahresbericht*. AAA is available since 1985 in computer-readable form. It is now available in the PHYS on-line bibliographic database supported by the FIZ (Fachinformationszentrum für Physik, Karlsruhe).

Titles and abstracts help, but evidently fall short of what could be possible with full-text retrieval. The copyright situation casts a long shadow over what is technically feasible and – on the part of the end-user – desirable. Preprints, though, are usually in a sort of benevolent zone. Their transitory nature allows them to partially escape from otherwise stringent proprietary controls. The value of having preprints on-line is inestimable for three reasons: (i) savings of paper and postage, (ii) speeding-up of the transfer of information to the scientific consumer, and (iii) opening up of the possibility of using full-text retrieval mechanisms.

A line-mode preprints server, covering astronomy as well as other areas of physics, is run by the International School for Advanced Studies in Trieste. Access by mail is supported, as is a mail-based alert system for new contributions, and anonymous ftp (to *babbage.sissa.it*). Thus far, the number of astronomy-related papers is not large.

The preprint situation at CERN is inspirational. The CERN printshop outputs 60 million A4 pages per year, of which 20% are preprints. Standardization on printer systems which adhere to the PostScript standard has reduced production time of preprints from weeks to days. Spurred on by speedier appearance, submission of preprints in PostScript by authors rose from 5% to 60% in one year. PostScript is, of course, the page description standard supported by most text processing systems (TeX and LaTeX, MS Word, PageMaker, WordPerfect, most graphics packages, etc.). The next step was to further reduce delays from scientific producer to scientific consumer by simply having permanent on-line access to all preprints. Figure 4 shows an example of the use of the X-Windows interface to this server. Preprints can be pulled over at the proverbial drop of a hat. A simpler line-mode interface is also supported.



```
1992ApJ...389..157W: WILLIAMS  O.R., TURNER  M.J.L., STEWAR
    R.D.,  OHASHI T., MAKISHIMA K., KII T., INOUE H., MAKIN
    K. and KOYAMA K. <Astrophys. J.,389,157,1992.>
    The  X-ray spectra of high-luminosity  active galactic
    by GINGA.

1992ApJ...389L...1M: MADAU P. <Astrophys. J.,389,1-4,1992 (
    The  contribution   of  quasars   to  the   ultraviolet
    background.

1992ApJ...390..359K:    KOFMAN   L.    and    RAGA    A.C.
    J.,390,359-364,1992.>
    Modeling structures of knots in jet flows with the Burge

1992BAAS...23.1395S: SCHONFELDER V., COLLMAR  W.,  DIEHL  R.
    MUCH R., STEINLE H.,  STRONG A.,  VARENDORFF M.,  BLOEM
    H.,  DEN  HERDER   J.W.   and   et   al.   <Bull.   Amer
    Soc.,23,1395,1992.>
    First preliminary results from COMPTEL.

1992Nat...355..299B: BIGNAMI G.F <Nature,355,299,1992.>
    Gamma-ray power from 3C 279.

1992SSRev..59..315W: WEEKES T.C. <Space Sci. Reviews,59,315,
    TeV radiation from galactic sources.
```

```
simbad/bib "3c 273
```

Figure 3: *Matching data on 3C 273 from various databases, and from the literature, using ESIS's Correlation Environment.*

5. The Late 20th Century's Lingua Franca

We may have different national origins, but we all now speak one language: tpc/ip. A mild exaggeration perhaps, not least because various other computer communication protocols can make themselves understood loudly and clearly to the tcp/ip protocols. Furthermore middle-level, hand-shaking, data-transferring protocols such as tcp ("transmission control protocol") and ip ("internet protocol") are not as user-relevant as even higher-level protocols. In this section, we will look at what is possible using some of these higher-level standards.

The basis of fact in this section's title is that the Internet is closely related to these protocols. The internet is made up of a large number of backbone, regional and local data networks.

The Usenet/Internet newsgroup system presents a daunting and fascinating communication subsystem. An estimated 60,000 sites have access to the 8000 newsgroups and about 1.6 million users at these sites are newsreaders. The approximate 16,000 message postings per day correspond to over 40 megabytes of traffic. Of course the signal-to-noise ratio is not always high: today's undergraduate students get their term papers done by posting a question, and waiting for the answers to roll in.

Cleverly, though, it has been noted that even low-grade questions can play a beneficial role. In many newsgroups, a FAQ (Frequently Asked Questions) posting is regularly updated. The FAQ (including answers) for the astronautic newsgroup, sci. space, for instance, comprises 170 kilobytes. A FAQ is a paradigmatic dynamic document, which collects many of the most frequent questions and answers. FAQs are pedagogical documents par excellence and can be availed of by anyone seeking a quick grounding in a particular subject.

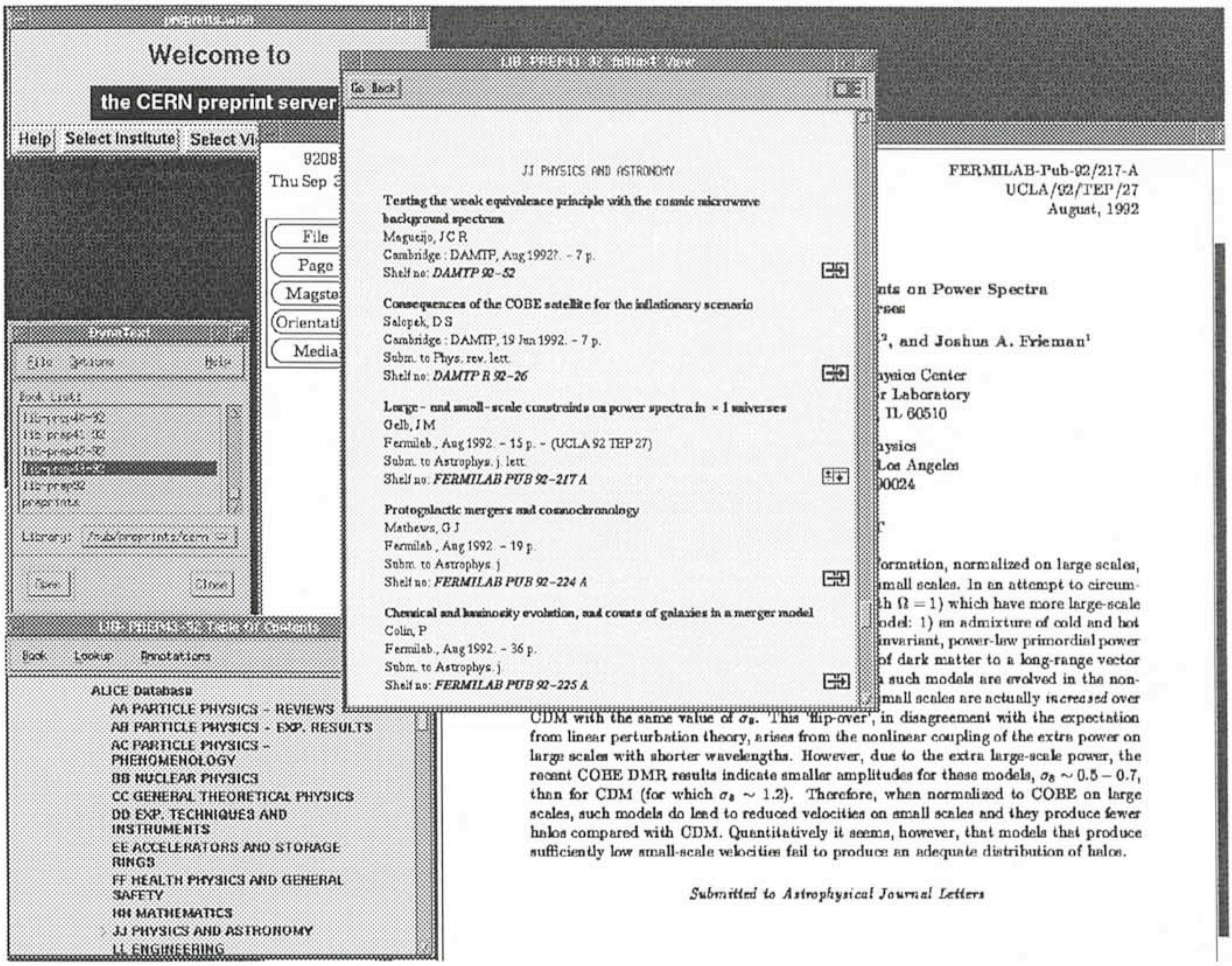
The common data transfer protocol (and command name) on the Internet is ftp ("file transfer protocol"). Anonymous ftp has become a standard way to make datasets, documentation, and code available.

A qualitative step forward is currently taking place in regard to what is available through anonymous ftp. Indexing and stock-taking of what is available is increasingly being carried out in an automated way. The archive server, archie, regularly polls 1000 anonymous ftp sites, seeking out updated directory listings at these sites. "Browsing through terabytes" of text, of software code, and of other data, has become the operative principle.

A number of other distributed information retrieval systems have also come to prominence in recent times. A system called WWW ("World-Wide Web") supports Internet-wide hypertext. Try it, with its simplest access interface: telnet to info.cern.ch (no password). WAIS ("Wide Area Information Server") is a network-wide information retrieval tool. To quickly try out WAIS, the author indexed 125 papers and book chapters in one of his subdirectories. The indexes were established for approximately half a million words in a few minutes. A natural-language query (Fig. 5: "Everything you've got on the VLT . . .") yielded a thoroughly acceptable set of documents. This tool, though, aims at *distributed* information retrieval, accessing remote servers. If the information exists, and is set up approximately for WAIS, then it will be found. WAIS represents one line of attack on the "resource discovery" problem. It is a step on the way towards unleashing the genie in the computer networks which are now commonplace in research.

6. From Palette of Tools to Chiaroscuro of Knowledge

The developments overviewed here are driven by one consideration: there is no alternative. Mounting quantities (and



JJ PHYSICS AND ASTRONOMY

Testing the weak equivalence principle with the cosmic microwave background spectrum
Magueijo, J C R
Cambridge : DAMTP, Aug 1992?. - 7 p.
Shelf no: ***DAMTP 92-52***

Consequences of the COBE satellite for the inflationary scenario
Salopek, D S
Cambridge : DAMTP, 19 Jun 1992. - 7 p.
Subm. to Phys. rev. lett.
Shelf no: ***DAMTP R 92-26***

Large - and small-scale constraints on power spectra in = 1 universes
Gelb, J M
Fermilab., Aug 1992. - 15 p. - (UCLA 92 TEP 27)
Subm. to Astrophys. j. lett.
Shelf no: ***FERMILAB PUB 92-217 A***

Protogalactic mergers and cosmochronology
Mathews, G J
Fermilab., Aug 1992. - 19 p.
Subm. to Astrophys. j.
Shelf no: ***FERMILAB PUB 92-224 A***

Chemical and luminosity evolution, and counts of galaxies in a merger model
Colin, P
Fermilab., Aug 1992. - 36 p.
Subm. to Astrophys. j.
Shelf no: ***FERMILAB PUB 92-225 A***

ALICE Database
AA PARTICLE PHYSICS - REVIEWS
AB PARTICLE PHYSICS - EXP. RESULTS
AC PARTICLE PHYSICS - PHENOMENOLOGY
BB NUCLEAR PHYSICS
CC GENERAL THEORETICAL PHYSICS
DD EXP. TECHNIQUES AND INSTRUMENTS
EE ACCELERATORS AND STORAGE RINGS
FF HEALTH PHYSICS AND GENERAL SAFETY
HH MATHEMATICS
JJ PHYSICS AND ASTRONOMY
LL ENGINEERING

FERMILAB-Pub-92/217-A
UCLA/92/TEP/27
August, 1992

nts on Power Spectra
rses

, and Joshua A. Frieman[1]

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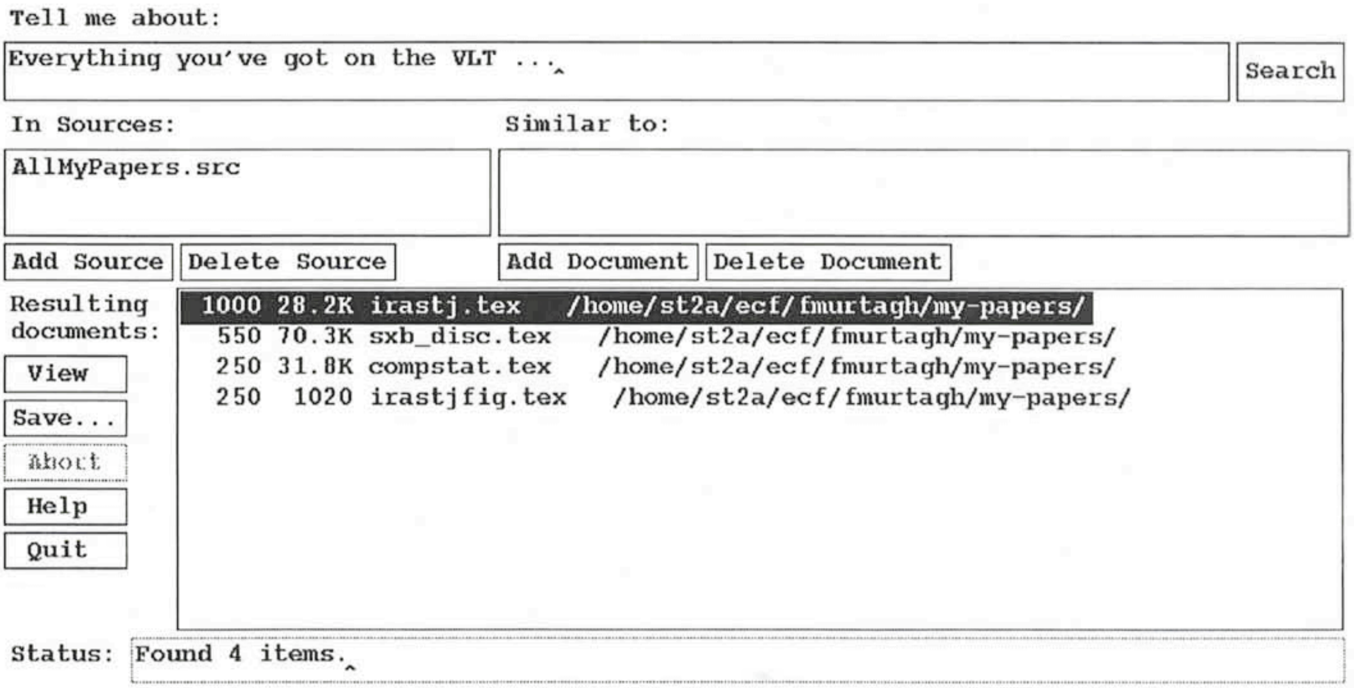
ormation, normalized on large scales,
mall scales. In an attempt to circum-
h $\Omega = 1$) which have more large-scale
odel: 1) an admixture of cold and hot
invariant, power-law primordial power
of dark matter to a long-range vector
such models are evolved in the non-
mall scales are actually *increased* over
CDM with the same value of σ_8. This 'flip-over', in disagreement with the expectation from linear perturbation theory, arises from the nonlinear coupling of the extra power on large scales with shorter wavelengths. However, due to the extra large-scale power, the recent COBE DMR results indicate smaller amplitudes for these models, $\sigma_8 \sim 0.5 - 0.7$, than for CDM (for which $\sigma_8 \sim 1.2$). Therefore, when normalized to COBE on large scales, such models do lead to reduced velocities on small scales and they produce fewer halos compared with CDM. Quantitatively it seems, however, that models that produce sufficiently low small-scale velocities fail to produce an adequate distribution of halos.

Submitted to Astrophysical Journal Letters

Figure 4: *The CERN preprint service. Shown are windows with a subject list, a recent preprint list, and the full text corresponding to one such preprint. A hypertext system facilitates navigation through all of this information.*



Tell me about: Everything you've got on the VLT ...

In Sources: AllMyPapers.src

Similar to:

Resulting documents:

```
1000 28.2K irastj.tex    /home/st2a/ecf/fmurtagh/my-papers/
 550 70.3K sxb_disc.tex   /home/st2a/ecf/fmurtagh/my-papers/
 250 31.8K compstat.tex   /home/st2a/ecf/fmurtagh/my-papers/
 250  1020 irastjfig.tex   /home/st2a/ecf/fmurtagh/my-papers/
```

Status: Found 4 items.

Figure 5: *A WAIS query ("Tell me about:") and results (on a set of the author's papers, which had been indexed beforehand).*

quality) of data require such steps to produce the global and integrated picture of information and knowledge.

7. To Probe Further

For material throughout, see inter alia Albrecht and Egret (1991), and Heck and Murtagh (1992).

Section 1: See Pirenne and Ochsenbein (1990 – to be updated soon).

Section 2: For STARCAT, see Pirenne et al. (1992).

Section 3: For ESIS, *set host* to *esis* (29671) and login with username *esis* (no password); or telnet to *esis.esrin.esa.it* (192.106.252.127), again using username *esis* with no password. On the Correlation Environment, see Giommi et al. (1992).

Section 4: For SIMBAD, see Egret et al. (1991). For contact points of commercial database providers, see Watson (1991). On the CERN preprint server, see van Herwijnen (1992).

Section 5: For FAQs, see Higgins and Leech (1992). For archie see Feigelson and Murtagh (1992). For archie, Gopher, WAIS and WWW, see contributions in Heck and Murtagh (1993).

Acknowledgements

Thanks to: M. Albrecht, R. Hook, B. Pirenne and R. Albrecht, for comments, and to S. Ansari and E. van Herwijnen for some of the material used.

References

1. M.A. Albrecht and D. Egret (Eds.) *Databases and On-Line Data in Astronomy*, Kluwer, Dordrecht, 1991.
2. D. Egret, M. Wenger and P. Dubois, "The SIMBAD astronomical database" in M.A. Albrecht and D. Egret, Eds., *Databases and On-Line Data in Astronomy*, Kluwer, Dordrecht, 1991, 79–88.
3. E.D. Feigelson and F. Murtagh, "Public software for the astronomer: an overwiew", *PASP*, **104**, 574–581, 1992.
4. P. Giommi et al., "The ESIS Correlation Environment prototype", in D.M. Worrall, C. Biemesderfer and J. Barnes, Eds., *Astronomical Data Analysis Software and Systems I*, Astronomical Society of the Pacific, San Francisco, 1992, 59–61.
5. A. Heck and F. Murtagh (Eds.), *Astronomy from Large Databases II*, ESO Conference and Workshop Proceedings, 1992.
6. A. Heck and F. Murtagh (Eds.), *Adding Intelligence to Information Retrieval: The Case of Astronomy and Related Space Sciences*, Kluwer, Dordrecht, 1993, forthcoming.
7. W. Higgins and J. Leech, "Compiling answers to frequently asked questions about space on computer networks", in *Proc. 43rd. Congress of the International Astronautical Federation*, Aug. 28–Sept. 5, 1992, in press.
8. B. Pirenne, M.A. Albrecht, D. Durand and S. Gaudet, "STARCAT: An Interface to Astronomical Databases", in A. Heck and F. Murtagh (Eds.), *Astronomy from Large Databases II*, ESO Conf. and Workshop Proc., 1992.
9. B. Pirenne and F. Ochsenbein, "New media for data distribution and exchange in astronomy", *ST-ECF Newsletter*, No. 12, Jan. 1990, 11–12.
10. E. van Herwijnen, "Are document servers replacing journals?", preprint AS/MI-92-05, CERN, 1992.
11. J.M. Watson, "Astronomical bibliography from commercial databases", in M.A. Albrecht and D. Egret, Eds., *Databases and On-Line Data in Astronomy*, Kluwer, Dordrecht, 1991, 199–210.

ESO Computer Networking

R. Hook, ST-ECF

1. Introduction

Astronomy has always been an international subject from the historical link to navigation up to the modern requirement to erect telescopes at the best sites in the world regardless of distance. ESO is itself a fine example of this trend – what could be more international than a collaborative organization of eight different countries running an observatory in the opposite hemisphere? Efficient operation requires efficient communications and in the era of predominantly digital data and text processing this means efficient computer networking.

Networking has now advanced enough that it reaches most astronomical sites world wide. Operations such as sending electronic mail from an Institute in Estonia to a student observing at La Silla are now taken for granted although they would have been unthinkable in more ways than one twenty years ago. Another important recent development, which is totally dependent on networks, is remote observing in Chile directly from an institute in an ESO Member State without either the astronomers having to travel to Garching to the remote control centre or all the way to Chile. This successful experiment was described in detail in the last edition of *The Messenger*.

Despite these huge improvements, networking still has a long way to go before it becomes as consistent and easy to use as the telephone or FAX machine. There are several different networks in use and they all have their quirks, foibles and inconsistencies. They are also often too slow and sometimes don't work. This article describes briefly the most important current networks used by astronomers. It then describes in more detail how external users may contact ESO electronically and what facilities are available. People who are already familiar with the networks may find most of the important information they need in the box which summarizes ESO electronic contact points. The text inevitably uses rather a lot of acronyms for conciseness. These are explained in Table 1 which should be consulted when necessary.

2. The Main Networks

Computer networks have tended to expand from modest systems linking workers in a similar discipline or geographical area to huge "internets" spanning the globe and united by the use of a common protocol. The protocol may be thought of as the standardized set of rules for communication which is independent of the type or manufacturer of computer equipment. There are now two main "protocols" which are dominating international science networking. They are the TCP/IP protocols used by the Internet and the set of standard protocols defined by the International Standards Organization (ISO) and often referred to as OSI. In addition there are several other protocols in use which astronomers encounter, in particular DECnet (used by the SPAN network), Bitnet/EARN and UUCP. To some extent these may be used together. For example it is quite common for TCP/IP or DECnet to be implemented "on top of" the lower level OSI protocol X.25.

Table 1: *Networking Acronyms*

BITNET	"Because it's time" network
CISCO	Major manufacturer of network routers
CUNY	City University of New York
CWI	Company contracted to provide Dutch networking
DATEX-P	DBP's packet switching (X.25) system
DFN	Deutsches Forschungsnetz
DLR	Deutsche Luft- und Raumfahrt
DBP	Deutsche Bundespost Telekom
EARN	European Academic Research Network
Ebone	European backbone network
ECRC	European Computer Industry Research Centre GmbH
EUnet	European UUCP network
E-SPAN	European-SPAN
ESOC	European Space Operations Centre
ESTEC	European Space Technology Centre
STECF	Space Telescope European Coordinating Facility
STScI	Space Telescope Science Institute
GSFC	Goddard Space Flight Center
ISO	International Standards Organization
MPE	Max-Planck-Institut für Extraterrestrische Physik
OSI	Open Systems Interconnect
SPAN	Space Physics Analysis Network
TCP/IP	Transmission Control Protocol/Internet Protocol
UNIDO	University of Dortmund
UUCP	Unix to Unix Copy Protocol
WIN	Wissenschaftsnetz

2.1 The "Internet"

This network began in the US military (as ARPAnet) but has rapidly expanded in the US and joined up with other networks using the TCP/IP protocol to form what is now the largest global computer network used by astronomers. The total number of hosts worldwide is now close to one million. The word "internet" can be confusing – an "internet" is a group of "networks" which are linked together to form a single entity but the term "the Internet" (capital "I") is normally used to mean the global internet using the TCP/IP protocol. The Internet will be the dominant international science network of the next decade.

Every Internet host has a unique address which is normally written as four numbers separated by dots, e.g. 134.171.8.120. The addresses of all ESO machines begin "134.171.". Host names follow a hierarchical system using domains. Examples are "mc6.hq.eso.org" (a main UNIX computer at Garching), "lw0.ls.eso.org" (a UNIX machine at La Silla), "foca.stsci.edu" (a VAX at STScI) and "simbad.u-strasbg.fr" (the SIMBAD server at CDS Strasbourg). Typically the last part of the name (the domain) is either a country code (.de, .fr, .es, .jp, .se, .nz, etc.) or one of a few special cases such as ".edu" (used mainly for US academic hosts) or ".mil" (US military). The domain ".org" is used for international organizations not fitting into any other class, hence all ESO machines have names ending in ".eso.org" – ".hq.eso.org" for hosts at Garching and ".ls.eso.org" for La Silla hosts.

2.2 DECnet Networks

In the 1980s scientific computing was dominated by VAX computers and it was convenient to link them up using the protocol supplied by their manufacturer which is called DECnet. The most familiar DECnet network used by astronomers is called SPAN (the Space Physics Analysis Network) which has expanded from space physics to cover many astronomical sites worldwide. However, the general move away from VAX computers to higher performance UNIX machines as well as the desire to avoid dependence on single vendors has also led to the TCP/IP Internet largely superseding DECnet for astronomical communications, particularly in the USA. However, in Europe many sites still rely on SPAN and are not accessible via the Internet. DECnet nodes are identified by a name (with a maximum of six characters), this is equivalent to a number which may also be used if the name is not known on the local system. The new DECnet (Phase V) will move much closer to OSI standards but it is not clear that it will be widely used throughout the astronomical

ESO Electronic Contact Point Summary

Electronic Mail:

Usernames are normally first initial plus surname, truncated to 8 characters. Addresses take the form:

Internet:	user@eso.org	(preferred)
DECnet/SPAN:	eso::user -or- 28760::user	
Bitnet/EARN:	user@dgaeso51.bitnet	
UUCP:	user@eso.uucp -or- eso!user	
PSI mail:	Not supported	

Remote Login:

ESO supports several remote login facilities on the Garching "network host" (mc3.hq.eso.org = 134.171.8.4). This machine is also accessible over X.25 at the number 0262458900924 and via telephone modems (numbers on request, not recommended). There is no direct DECnet access.

Bulletin Boards:

Simple news facilities based on USENET News are available on the network host. Login as:

esobb – for general ESO news including La Silla schedules, MIDAS news, instrument news, etc.

stinfo – for news about the Hubble Space Telescope.

Anonymous FTP:

ftphost.hq.eso.org (134.171.8.4) – for general ESO files and ESOFORM.

ecf.hq.eso.org (134.171.11.4) – for Space Telescope related files.

In case of problems:

Send mail to "postmaster" at one of the addresses given above. If all else fails, telephone one of the Garching computer support staff:

Peter Dierckx	–	+49 89 32006-387
Renny de Roos	–	+49 89 32006-445
Richard Hook	–	+49 89 32006-389
Carlos Guirao	–	+49 89 32006-434

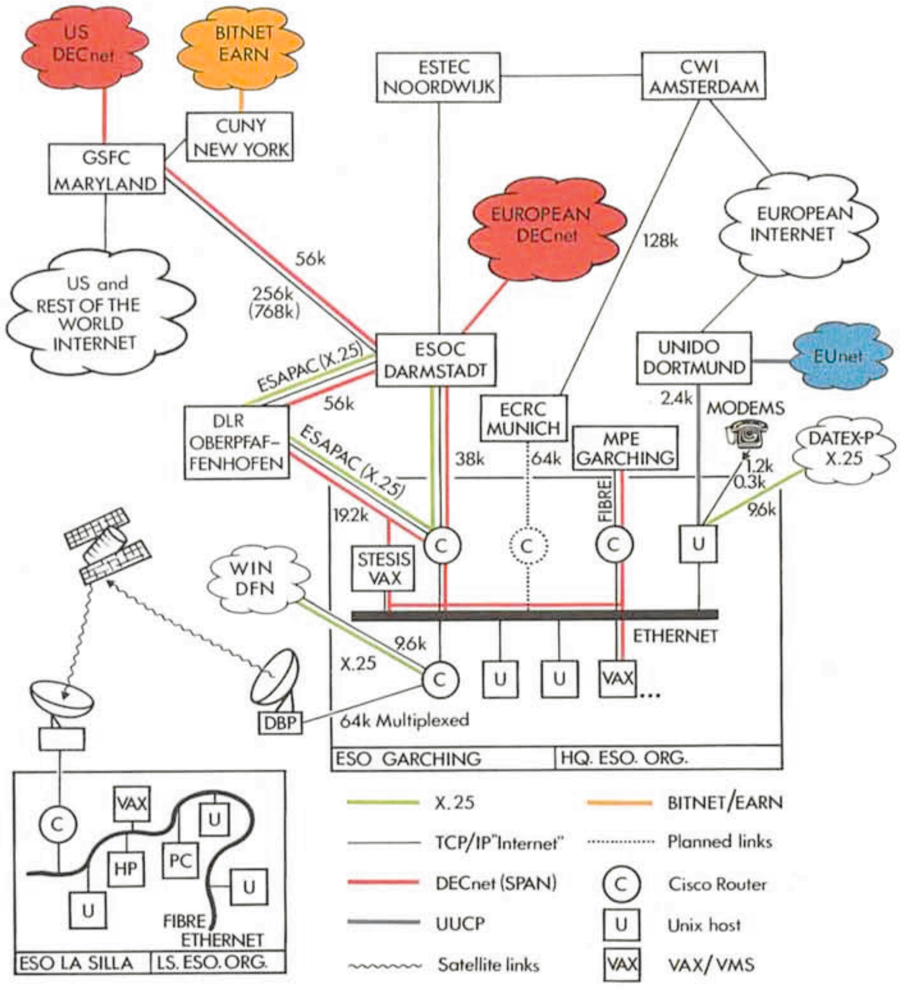


Figure 1.

world. The main ESO VAX for communication has the host name ESO (= 28760). La Silla is not directly accessible over DECnet.

2.3 Bitnet and EARN

These two networks use the same protocols and differ only in that the former is mainly confined to North America and the latter to Europe. They are based on the RSCS protocol developed by IBM, and many of the machines initially using this network were IBM mainframes. However other implementations (e.g. for VAXes) have been produced and are widespread. In the early days the networks were financially strongly supported by IBM which made them attractive. However the rise of the Internet has made their use start to decline. Bitnet/EARN is now primarily used for electronic mail but can support other facilities, such as file transfer, although these facilities are only likely to be used in conjunction with IBM computers. ESO retains the clumsy name DGAESO51 for electronic mail but is no longer directly connected to Bitnet/EARN.

2.4 UUCP

UUCP is a simple network system which originated as a way of connecting UNIX machines together over telephone modems. It is now little used in astronomy and is included here only because ESO has a UUCP link to the University of Dortmund and may be contacted at the address eso.uucp.

3. ESO Networking Configuration

Most ESO computers in Garching and La Silla run the UNIX operating system, but there are still a few VAX machines running VAX/VMS. As a matter of policy all the machines support the TCP/IP protocol and hence they can all communicate with each other and with the external Internet. Only the VAXes are also connected to SPAN although electronic mail may be sent between SPAN and the UNIX machines by using one of the VAXes as a gateway. Only TCP/IP is supported on the link between Garching and La Silla which is a multiplexed line also for other types of communications (e.g. remote observing).

ESO is directly connected to the Internet, DECnet (SPAN) and UUCP. Mail may be sent to and from Bitnet/EARN via gateways on the Internet. The configuration is shown in simplified, but still rather complex, form as Figure 1. In order to make it compact acronyms are used a great deal and these are explained in Table 1. Both SPAN and Internet traffic currently uses a line between Garching and ESOC which was originally established for communications between the Space Telescope Science Institute in Baltimore and the Space Telescope – European Coordinating Facility, which is based at ESO. Most European Internet traffic is routed from this ESA network onto the European high speed backbone (the Ebone) in Holland. Traffic for the rest of the world goes initially to Goddard Space Flight Center in the USA. This ESA link is an effective temporary solution but in the medium term ESO is planning to get its own high speed link into the Internet. One possibility which is being considered in detail at present is a new connection which will link ESO Garching with a "Point of Presence" in Munich and from there to the Ebone via Amsterdam. This link will allow comparable or better performance to the present system without having to use ESA lines originally installed for a different use. However, it must be stressed that this new link is far from being finalized yet and it may not prove to be possible in the form given here.

Other lines out of ESO include a slow telephone modem link to Dortmund which carries some electronic mail (e.g. UUCP mail), an X.25 connection to the German DATEX-P public packet switching network and an X.25 link into the German Wissenschaftsnetz (WIN) which also can carry Internet protocol traffic at low data rates.

4. Sending Mail to ESO Staff and Visitors

Most ESO Staff at both Garching and La Silla have a username on a UNIX computer. These usernames are normally the initial letter of the person's first name, followed by their surname and with the result truncated to eight characters, all in lowercase. E.g., the username of a hypothetical Helmut Mitterand would be "hmittera". The same rule is used at both Garching and La Silla. Once the username has been deduced, a message may be sent to one of the standard ESO addresses given in the summary box. It is not necessary to either specify a particular machine at Garching or La Silla. Typical addresses would be "hmittera@eso.org" or "hmittera@dgaeso51.bitnet" or "eso::hmittera". It should be noted that every UNIX username has a unique mail delivery point and sending messages to specific machines in Chile or Garching will probably result in the message arriving at the same place anyway even if the user has a username on several different machines.

Visitors to La Silla may be contacted by sending mail to the special account "lasilla" at the same address. This is read regularly at La Silla and a message may be delivered to the required person. To make the recipient clear the "subject" line should specify whom it is intended for.

Electronic Network Access to ESO

for Image Processing Group, P. GROSBØL

November 13, 1992

The main emphasis for ESO's Wide Area Network connections will be placed on providing a fast and reliable access through Internet although connections to SPAN, EARN and UUCP will be maintained as long as it is reasonable considering both usage and cost. During the major part of this year, ESO has been allowed to route a significant part of its Internet traffic through an ESA/NASA link. This has significantly contributed to the stabilization and been greatly appreciated by both ESO and its user community. ESO is now in the process of establishing a faster and more direct link to the European Internet Backbone to accommodate the increasing network traffic.

5. Other ESO Networking Facilities

ESO provides a number of facilities which may be accessed via the networks. Firstly there are two anonymous FTP accounts which may be reached by anyone on the Internet. The first of these is ESO specific and provides MIDAS software updates and general information. The second is maintained by the ST-ECF and contains files relevant to HST's operation. In particular there is a large software library from many sources and documents and software useful for proposal preparation. The addresses of these FTP accounts are given in the summary box. They are accessed in the usual way–connect to the machine using FTP and give "anonymous" as the username and your electronic mail address as the identification string when prompted.

In addition, two Bulletin Board systems may also be accessed over the Internet. They provide access to up-to-date information using the USENET News system. The first, "esobb" gives information about the ESO computer systems, MIDAS news and other news for visitors to Garching or La Silla. The second is for HST news and has the username "stinfo". Again the details are given in the summary box. Just login and try them, no password is required.

It is also possible to access the ESO/ST-ECF STARCAT system over the network. STARCAT provides access to the Hubble Space Telescope catalogue and the ESO Archive catalogue as well as many other astronomical catalogues and data bases. There are two kinds of access. Firstly one may login to the account "starcat" on the Internet host dbhost.hq.eso.org or to the DECnet host STESIS (28771). These are captive accounts which have no password but give interactive access to the STARCAT system.

It is often inefficient to use STARCAT interactively over a slow network link. To provide an effective way of issuing STARCAT commands remotely in a batch style, a new facility called STARMAIL is now available. To use this, one prepares a set ot STARCAT commands remotely and sends them as an electronic mail message to "starmail" at the standard ESO addresses. The commands are automatically issued to STARCAT and the resultant output is returned to the remote user by electronic mail. For more details please contact Miguel Albrecht (username "malbrech"). STARMAIL will be described in detail in the forthcoming *ST-ECF Newsletter* (Number 19, January 1993).

A final and important new networking facility is the support of electronic observing time proposal submission and validation for the ESO La Silla telescopes. This system is called ESOFORM and it is a three-stage process:

1. Collect the LaTeX style files and proposal validation software from the ESO anonymous FTP. The directory is eso/proposal and the file which should be collected (using binary FTP) is the compressed "tar" file esoform-NN.tar.Z where NN is the ESO observing period number e.g. 52). Alternatively the files may be copied over DECnet from the directory ESO::ANONYMOUS:[ESOFORM].
2. Prepare the proposal in the correct form on the local machine using the LaTeX style files and template provided and validate it using the software which is also available from the same place.
3. Send the completed proposal to the username "proposal" at the standard ESO addresses. The text sent will automatically be validated on arrival and a message returned to the sender either notifying him/her that the proposal has been validated correctly and has been passed on to the ESO Observing Programmes Committee (OPC) or that it failed validation and will have to be re-submitted.

6. A Bright Future

The near future plans for ESO are based on getting improved TCP/IP communications between Garching, La Silla and the astronomical community. Other protocols will be maintained where they are required but are likely to fade away quite quickly as the demand for them from other institutes also fades.

At present the revolution in the way astronomers use computer networks is just beginning. There are three main changes which will inevitably happen over the next few years. Firstly there will be much greater line speeds, these are obtainable easily using current fibre-optics technology, the delays are practical and financial. End-to-end speeds of roughly a Megabit/s should be attainable throughout Europe within five years. In the US, where TCP/IP networking is far more advanced, such speeds are already available between some sites. Improvements of this magnitude would, for example, allow a future Hungarian ESO astronomer to display a CCD image which had just been taken by the VLT in a few seconds on their own workstation in Budapest. The second change will be the global adoption of more compatible protocols, almost certainly using TCP/IP as the *lingua franca*. This change is already well advanced and will allow the vast majority of computers worldwide to talk to one another. The final change may prove to be the most important for the actual user. Once networks become compatible and fast, the mechanisms of moving information around on them will become less obvious and the systems will become more distributed. Instead of users invoking basic network facilities (ftp, mail and telnet) more advanced tools (probably using a graphical user interface based on X11) will use the net as and when required, rather as a current ethernet is used within an organization. In such an environment finding and organizing information will become more of an obstacle to effective research than the practical aspects of how to move information around. These issues are addressed by Fionn Murtagh's article in this edition of *The Messenger*.

7. Acknowledgements

I would like to thank the many people at ESO and the ST-ECF who provided helpful comments on the manuscript of this article and particularly Miguel Albrecht who gave me detailed information about the proposal submission system and STARMAIL.

Report on ALD-II, Astronomy from Large Databases II

M. CRÉZÉ[1], A. HECK[1] and F. MURTAGH[2]

[1]Strasbourg Observatory, France; [2] Space Telescope – European Coordinating Facility

The colloquium on "Astronomy from Large Databases II" was held from September 14–16, 1992. It was a follow-up to a meeting with the same title ("Astronomy from Large Databases: Scientific Objectives and Methodological Approaches") held in Garching in 1987. The proceedings of both meetings were published by ESO.

If one considers the two terms of the title, "astronomy" and "large databases", then the aim of the conference was the directed link between these. Hence the objective was not so much to cater for new astronomical results – there are many appropriate fora for this – nor to deal thoroughly with database technicalities. Rather the aim was to share experiences, and to focus interests, along the interface between these areas.

The meeting was structured so as to prioritize discussion. Twenty-odd invited talks were complemented by around 70 posters which were on display throughout. A number of talks covered database and archive usage on the part of extant projects (IUE, HST, ROSAT, HIPPARCOS, COBE, etc.). Reference was made to the myriad databases constituting a back-drop to such large projects. Panchromatic astronomy is certainly the order of the day. Subsequent talks included coverage of: classification-oriented front-ends for databases; current research and perspectives in the information retrieval community; data security issues; the astronomer's research environment; and other topics. Poster papers covered such themes as: statistical and pattern recognition studies; visualization; quality control of data; thesauri; sky survey databases; and many descriptions of functionality offered by particular projects.

A feature of note, regarding this conference, was the fact that the role of libraries (paradigmatic large databases, of course, even if not always in electronic form) in astronomy was addressed. A discussion panel involving librarians from ESO, AAO and others, as well as the President of IAU Commission 5 (Data and Documentation), focused further on this topic. What is aimed at is nothing less than the increasingly better integration of data and information that the astronomer has to deal with, whether bibliographic, symbolic, numeric, image, or whatever. Following this conference, one no longer has any right to consider astronomical databases separately from the role played by astronomical libraries.

Conferences such as this are of great help in combating "photonic provincialism" (D. Wells). The lowering of boundaries, and the bridging of what were until recently distinct areas, can only be for the betterment of our science.

The New MIDAS Release: 92NOV

ESO Image Processing Group

The new 92NOV release of MIDAS is now available for general distribution. The one-year release cycle introduced last year has made it possible to extend the validation tests significantly. The current release is actually based on the development version of MIDAS frozen in August. This frozen version is first going through a one month α-test inside ESO, after which a β-test version is sent out to 5–10 test sites. The final release version is made in the course of November, taking into account the different test reports. We hope that this rigorous test procedure and full configuration control of the source code will provide a stable and reliable system for the users.

The introduction of source code control and other CASE tools for code production in MIDAS not only improves the development cycle but also provides interesting statistics as a side effect. The number of source code lines is shown in Table 1 for different types of files, where FORTRAN and C correspond to actual programme code, while prg refers to high-level MIDAS procedures. Documentation is mostly in the form of LaTeX or ASCII help files. In a few cases, the size has decreased due to revisions and rearrangements of old code. For the first time, the new release contains more C than FORTRAN code. The change is caused by a significant number of MIDAS core commands being optimized and rewritten in C. Most of the astronomical applications are still written in FORTRAN. The increase in MIDAS procedures indicates that many new commands are added by combining basic MIDAS applications, thereby reusing code already written. The 20% increase in documentation since the 91MAY release reflects the emphasis put on better documentation during MIDAS command verification in recent years.

The size of the source code can also be divided into the main MIDAS classes. As a sample, Table 2 shows some main categories, namely "core" MIDAS, graphic user interfaces (gui), system applications (applic), standard reductions (stdred) and general application packages (contrib). Whereas the basic system has been constant in size, a major increase for standard reduction packages and general applications can be seen in the last release. This is a direct result of the stabilization of the MIDAS core system which has enabled us to put more emphasis on new applications.

First Announcement of the 5th ESO/ST-ECF

DATA ANALYSIS WORKSHOP

ESO, Karl-Schwarzschild-Straße 2
D-W8046 Garching, FRG

April 26–28, 1993

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. The Workshop will be held at the ESO headquarters where there is room for 100 participants only. We may therefore have to reject some people and recommend you to register well before the deadline (1993-March-01) either through normal mail or E-mail.

The topic for the 1993 Data Analysis Workshop is the analysis of direct imaging. 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 the MIDAS user's meeting and special sessions.

The tentative agenda is as follows:

Analysis of Direct Imaging Data

April 26: 14:00–18:00: Surface Photometry
April 27: 09:00–12:30: Point Source Photometry
14:00–17:00: Time Series Analysis
17:00–18:00: European FITS Committee
April 28: 09:00–12:30: MIDAS users' meeting
13:00–14:00: European FITS Committee
14:00–17:00: User Interfaces and Data Acquisition

We especially welcome contributions on algorithms and techniques for: time series analysis of non-equally sampled data, calibration of photometry, and shapes of extended objects. We encourage people to present their work in these areas even if they are only ideas. After each introductory talk, there will be a more informal discussion where such contributions can be made. There will also be a poster session where people can present short contributions. The special session on Graphical User Interfaces and Data Acquisition will also include instrument control and on-line processing. Proceedings of the scientific sessions will be published.

The scientific organizing committee includes: P. Grosbøl (Chairman) P. Benvenuti
D. Baade S. D'Odorico
R. H. Warmels

Contact address: Resy de Ruijsscher,
Attn.: 5th Data Analysis Workshop,
European Southern Observatory,
Karl-Schwarzschild-Straße 2,
D-W8046 Garching, FRG.
E-mail: daw@eso.org (Internet)

Table 1: *Size of source code for different file types in units of 1000 lines*

MIDAS release	File type				
	FORTRAN	C	prg	$\LaTeX$	Help
90 MAY	211	175	26	42	24
90 NOV	210	199	23	41	24
91 MAY	191	180	33	48	29
91 NOV	210	204	29	59	34
92 NOV	217	275	34	62	36

Table 2: *Size of source code in different directories in Mbytes*

MIDAS release	Directory				
	"core"	gui	applic	stdred	contrib
91 MAY	12.4	–	1.4	1.9	2.0
91 NOV	11.5	–	1.4	1.5	3.4
92 NOV	12.0	3.5	1.5	2.4	5.0

The 92NOV release contains a large number of improvements and new applications. The table file system was significantly enhanced by making it possible to store arrays of values in individual elements. This makes it fully compatible with the Binary Table Extension proposed for FITS. Its basic routines were optimized so that it now can handle big tables with a size of over 100 Mbytes. Important new applications were added, such as a join of tables with uncertainties, which can be used for cross identification of objects in tables when only approximate coordinates are known. The FITS reader/ writer were upgraded to support the new proposed FITS extensions for Binary Tables and Images.

The graphic and display commands have been improved. More and better fonts were added to the plotting package, which also now provides more control to the user. The interactive "VIEW" command gives much better options to display images. The PostScript output files generated are now encapsulated and can be included more easily in other documents. A first set of Graphical User Interfaces has been included in this release to give a feeling for how the man-machine interface can be improved for MIDAS applications. The current interfaces were developed both at La Silla and in Garching as prototypes to evaluate different designs. They will be modified to conform to a general ESO Look

& Feel based on OSF/Motif depending on the user feedback.

Significant contributions were added in the application area as well. The IRSPEC reduction was revised by T. Oliva, while an image restoration and co-addition application, based on ideas of L. Lucy, was added by R. Hook (ST-ECF). A Time Series Analysis context, which includes analysis of non-equally spaced data, was made by A. Schwarzenberg-Czerny. Finally, a photometry scheduling programme was introduced by A.T. Young as the first application in a new context for calibrations of point-source photometry.

There are now more than 160 registered MIDAS sites, of which approximately 100 are in the ESO member States, 30 in other European countries and 16 in North America. Since many of these sites have several different computer systems, this represents a significantly larger number of installations. Our current statistics (not fully complete) show that 70% of the systems run UNIX, while the remainder have VAX/VMS. Of the UNIX systems, the distribution between different vendors is 42%, 21%, 15% and 7% for SUN/SPARC, DEC, HP/Apollo and IBM, respectively. The MIDAS site data-base as well as problem reports are available through the starcat account on the host dbhost.hq.eso.org.

A number of MIDAS information services are provided through Internet or e-mail. A bulletin board can be accessed by login on the esobb account on bbhost.hq.eso.org. Documentation and patches can be obtained through anonymous ftp from ftphost.hq.eso.org. General questions and problems can be mailed to the MIDAS hot-line account midas at eso.org.

FFT Removal of Pattern Noise in CCD Images

E. J. WAMPLER, ESO

1. Introduction

The second-generation CCD detectors at ESO have very greatly reduced readout noise. This noise reduction allows ESO astronomers to extend their observations to fainter sources. Unfortunately, with the lower detector background, electronic interference noise now often becomes the limiting background noise source. It is thought that this noise is mostly generated by the switching power supplies that are used in the CCD controllers (Roland Reiss, private communication). These are to be replaced in the near future by less noisy power supplies, but in the meantime it is useful to search for ways to remove the interference from existing frames as well as to develop tools to cope with possible future problems.

After experimenting with the MIDAS Fast Fourier Transform (FFT) packages, a simple way has been found to obtain a considerable reduction in the pattern noise seen in the ESO CCD frames. Because this method may be useful to others, it is described here in some detail. Briefly, the technique is a crude approximation of Wiener, or optimal, FFT filtering. See Brault and White (1971) or Press et al. (1988) for descriptions of Wiener filtering using FFT.

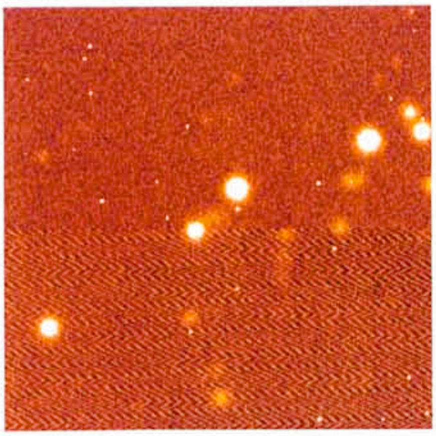


Figure 1: *A comparison of an unfiltered frame (lower half of the image) with a FFT filtered image (upper half).*

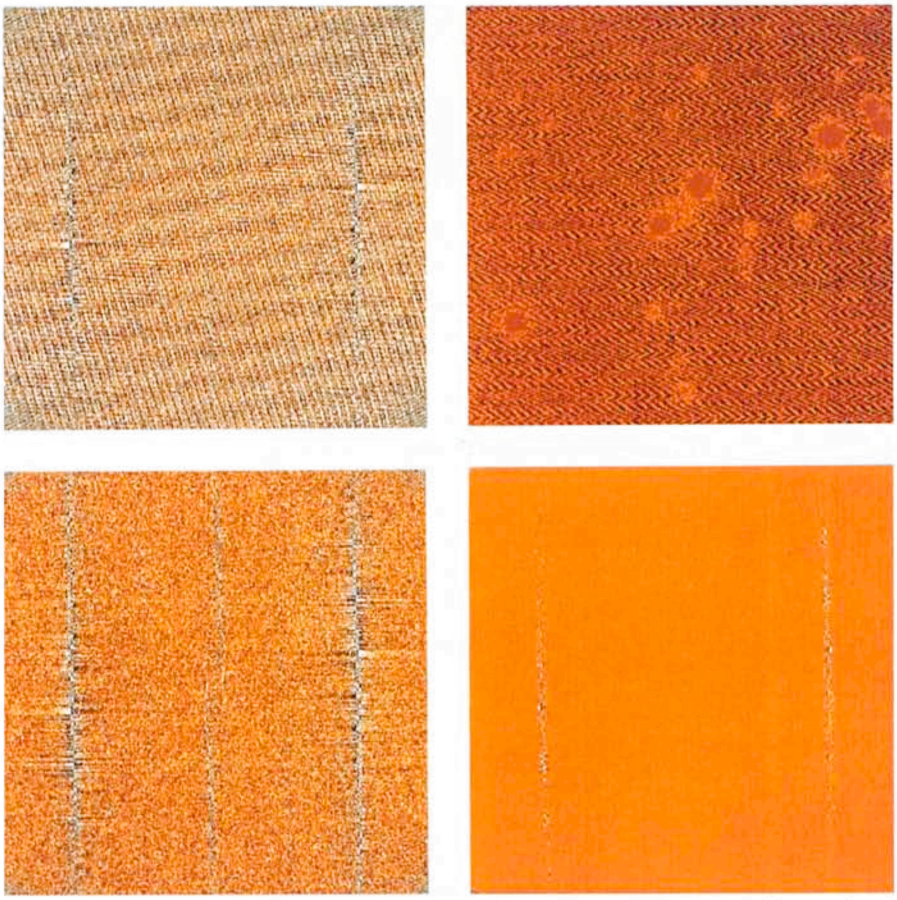


Figure 2: *Frames produced during the filtering process.* a: *The real FFT image of the raw input frame.* b: *The raw input frame with the stars replaced by the median value of the background.* c: *The real FFT image of the frame shown in panel b.* d: *The real FFT image after setting all low amplitude pixels (both positive and negative) equal to zero.*

2. FFT Cleaning of CCD Frames

Figure 1 shows a split-frame image of SN 1987 A taken with SUSI in September 1991 using a very narrow-band redshifted HeII λ4686 filter. The lower part of Figure 1 shows the received data frame, which is contaminated with electronic interference. The upper part of the figure shows a matching section of the same frame after using the cleaning procedure described here. The beginning steps of the procedure are shown in Figure 2. Frame 2a shows the real FFT image of the frame. For illustration purposes I am only showing the real image in the transform domain; the imaginary image is similar in appearance. The pattern in Figure 2a is dominated by the transform of the science data in the frame. The first step in separating the interference from the data and background noise is to remove as much as possible of the science signal from the data frame. First, any low frequency irregularities of the frame are removed. Then, using the MIDAS command STATISTICS/IMAGE, the median value of the background is determined and set to some convenient value. By using the MIDAS command REPLACE/IMAGE, all pixel values above the highest ones found in the noise signal are replaced by the background level. The result of this operation on the example given here is shown in Figure 2b. This modified frame is then transformed using FFT/IMAGE. The real part of the clipped image transform is shown in Figure 2c. Note that the background from the science signal, which, for our present purposes, behaves as a noise source, has now been greatly reduced. REPLACE IMAGE is used again to set all low amplitude components of Figure 2c and its imaginary counterpart to zero. The result of this operation is shown in Figure 2d.

This replacement procedure is similar to the application of a Wiener filter to the transform except that replacement by zero creates a filter function that is a truncation rather than a gradual roll-off. This is not too serious as we will iterate the resulting frame once. Because MIDAS does not have a simple procedure for constructing and applying FFT filters and because the FFT procedures are so fast, it takes less time to run through the procedures twice than it does to construct an optimal filter. In any case, the results of the interactive procedure described here, seem to be nearly as good as those that could be obtained by a more careful filtering procedure.

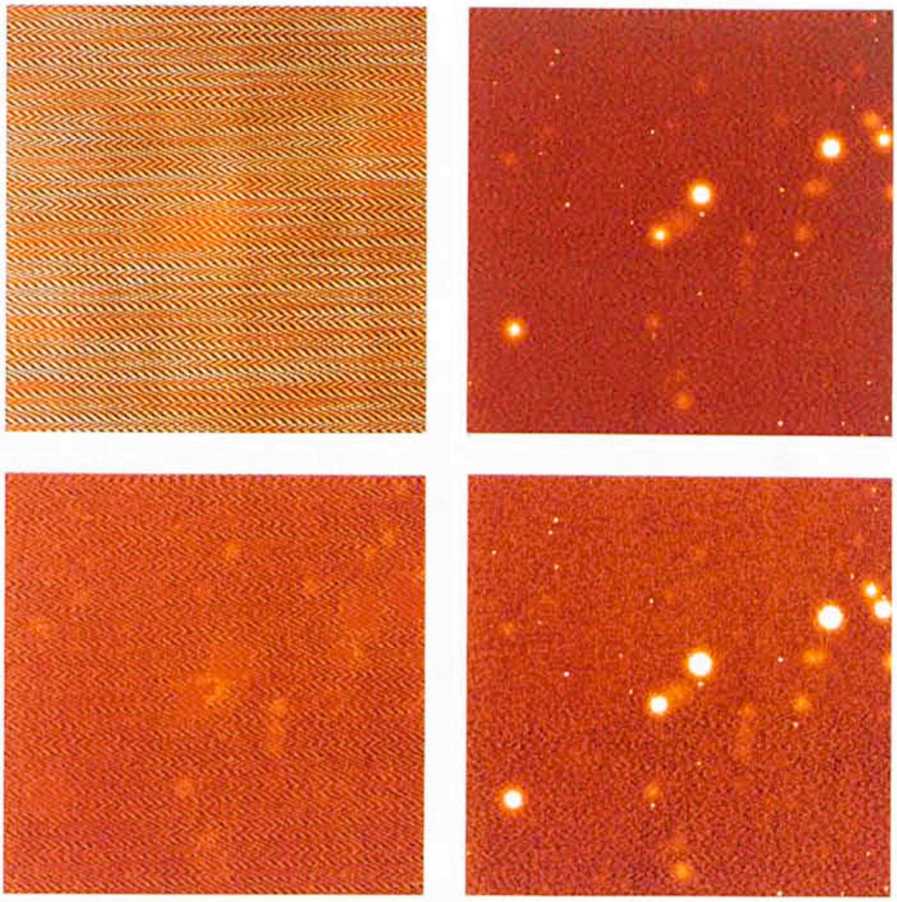


Figure 3: *Frames produced during the filtering process (continued).* a: *The inverse FFT of the filtered FFT frames (Fig. 2d). The interference pattern is now clearly seen with only a faint trace of the star images.* b: *The result of subtracting the pattern noise (panel a) from the input image. Note the imperfect cancellation of the pattern noise.* c: *The raw input frame with the star images replaced by an appropriate section from the FFT image of the pattern noise (panel a). Here the cosmic rays have also been replaced with the median background value.* d: *After the FFT of panel c was clipped, the new image of the inverse transform was subtracted from the raw input image. The resulting output image (upper half of the frame) is compared with the intermediate output from the first pass (panel b, lower half).*

The filtered images in the transform domain are transformed back to the measurement domain by using the MIDAS command FFT/INVERSE. This inverse transform results in real and imaginary frames which must be combined by taking the square root of the sum of the squares (remember that the square of an imaginary number is negative). Figure 3a shows the output frame. Note that both the science signal and the shot-noise in the input frame have now been greatly reduced, although faint evidence of the input signal at the positions of the bright stars can be seen. Subtracting the output frame from the input frame gives a substantial reduction of the pattern noise (see Fig. 3b). However, because a rather strong cut was used to filter the images in the transform domain some residual patterned structure remains in the background. For instance, note that a structured band still remains at the top of the frame. A strong cut of the frames in the transform domain was needed to suppress the science signal in the output image. But now that we have a first estimate of the pattern noise at the star positions in the input frame (Fig. 3b), we can replace those star images with this pattern. A mask for this can be produced from the star field by using the MIDAS commands REPLACE/IMAGE, FILTER/SMOOTH and then REPLACE/IMAGE again. Try to have the mask extend beyond the immediate neighbourhood of the star positions. Then by using REPLACE/IMAGE and INSERT/IMAGE the stars in the input image are replaced by the pattern image. This operation further reduces the signal from the science data and allows us to lower the cut values for the transform domain images. Figure 3c shows a second iteration of the FFT input frame and Figure 3d shows a comparison of the final output with the intermediate output.

Finally, Figure 4 shows the background statistics obtained for a patch of sky in the frames produced during the different steps of the pattern removal

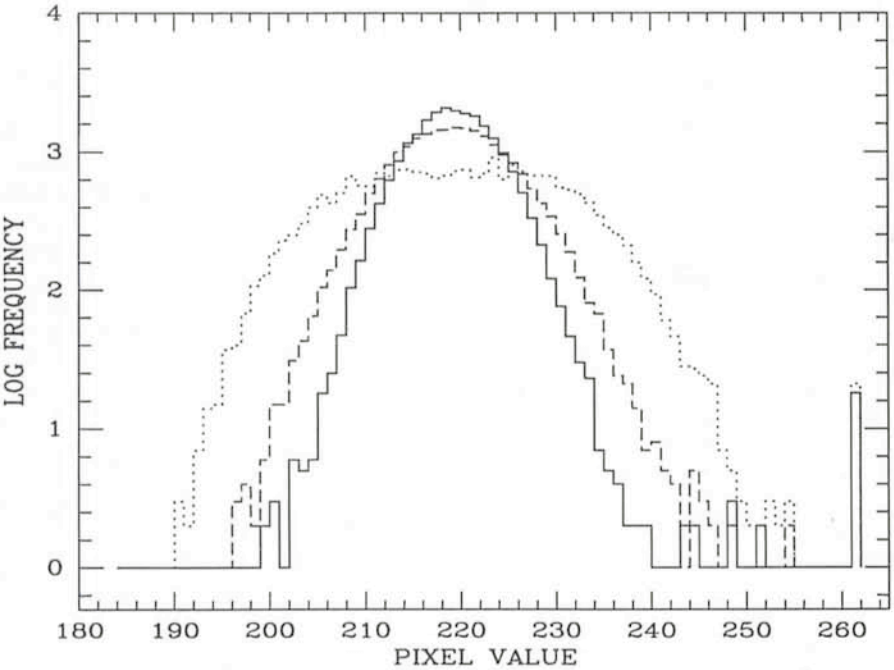


Figure 4: *The background statistics of the images. Dotted line: the input image; dashed line: an intermediate output; solid line: the final output. See the text.*

process. The distribution of pixel values for the input frame (dotted line) shows the wide, flat peak caused by the interference pattern noise. This is greatly reduced after the first pass through the FFT filter. At this stage the distribution of pixel values in the log-linear plot looks like an inverted parabola, suggesting that the distribution of values is nearly Gaussian. After the second iteration the width of the distribution has been further reduced, allowing improved detection of threshold stars. The use of a proper Wiener filter would result in optimal noise reduction but would require a MIDAS programme that could adjust the value of low amplitude signals in the transform domain by factors that depend on the signal amplitude. The cleaning procedure described here is logically very similar to the procedure by Adorf and Catchpole (1992) for creating a filter by isolating a domain in Fourier power space. The sharp edges of his domains are equivalent to a box filter, as is used here, rather than the optimal Wiener filter.

I am indebted to L. Lucy for pointing out the references to Wiener filtering.

References

[1] Brault, J.W. and White, O.R. 1971, *A & A.*, **13**, 169–189.
[2] Press, W.H., Flannery, B.P., Teukolwsky, S.A. and Vetteling, W.T. 1988, Numerical Recipes in C (Cambridge University Press, Cambridge) p. 434 ff.
[3] Adorf, H.M. and Catchpole, R. 1992, in *ST-ECF Newsletter*, February, 16–17.

Adaptive Optics on the 3.6-m Telescope: Latest News!

After several strenuous months of assembly and testing, the Come-On-Plus Adaptive Optics system has finally come to life in the "Laboratoire d'Interférométrie Infrarouge et d'Optique Turbulente (LYOT)" of the Observatoire de Meudon, under ONERA's supervision. Thanks to LASERDOT, who designed the control computer and the deformable mirror, the closed-loop 40-Hz bandwidth performance (at 0 dB) has been achieved. The LEP (Laboratoires d'Electronique Philips) delivered the EBCCD (see *The Messenger* No. **67**), a low-flux wavefront sensor detector, which is a quantum noise limited detector with a switchable frame frequency from 25 to 400 Hz. The 52-actuator deformable mirror has been tested with successful results. The actuators, made of a very hard piezoelectric material, show no hysteresis or heat dissipation at all, and the mechanical bandwidth is more than 10 KHz (far more than required for an atmospherical turbulence correction). The surface quality is also very good: by means of a self-correction, the mirror can lower its own wavefront residual error to less than 20 nm rms. The whole system is now ready to be tested on the sky, under real conditions in December 1992.

E. GENDRON and N. HUBIN, ESO

Where is MIDAS Available?

R. DE RUIJSSCHER, ESO

During the past years, the ESO MIDAS Image Processing System has been exported to a large number of scientific institutes in the world. The latest count shows that MIDAS is now available at about 160 institutes in 37 countries. For those who would like to know where, the list below indicates the date when the corresponding User Agreement with ESO was signed, the name of the institute and the location, arranged by country.

The MIDAS system is available, free of charge, to all non-profit research institutes, whereas other organizations or companies may be charged a nominal fee to cover distribution.

Institutes interested in using MIDAS must sign a User Agreement before distribution material can be shipped. The necessary forms can be obtained by contacting Resy de Ruijsscher at the Image Processing Group (ESO-Garching, address on the last page) or by sending an e-mail message to "midas@eso.org".

Date	Institute	Location
Argentina		
14 Jul 92	Instituto de Astronomía y Física del Espacio	Buenos Aires
Australia		
23 Jun 92	Mount Stromlo and Siding Spring Observatory	Weston A.C.T.
Austria		
05 Nov 90	Institut für Astronomie der Universität Innsbruck	Innsbruck
06 Nov 90	Institut für Astronomie der Universität Wien	Wien
23 Jun 91	Institut der Astronomie der Universität Graz	Graz
Belgium		
12 Nov 90	University of Antwerp	Antwerpen
18 Nov 90	Institut d'Astrophysique de Liège	Liège
18 Nov 90	Koninklijke Sterrewacht van Belgie	Brussel
25 Nov 90	Sterrenkundig Observatorium	Gent
17 Mar 92	Université Libre de Bruxelles	Bruxelles
Bulgaria		
15 Jun 92	Bulgarian Academy of Sciences	Sofia
Canada		
08 Jan 91	Dept. of Physics and Astronomy/ Univ. of Calgary	Calgary, Alberta
Chile		
08 Jan 92	Pontificia Universidad Católica de Chile	Santiago
31 May 92	Instituto Isaac Newton	Santiago
P.R. China		
12 Mar 91	Beijing Astronomical Observatory	Beijing
09 Sep 91	Shanghai Observatory	Shanghai
Czechoslovakia		
24 May 92	Ondrejov Observatory	Ondrejov
15 Jun 92	Astronomical Institute, Slovak Academy of Sciences	Bratislava
Denmark		
04 Nov 90	Niels Bohr Institut	Copenhagen
Estonia		
05 Nov 90	Tartu Astrophysical Observatory	Toravere
Finland		
02 Nov 90	University of Helsinki Observatory	Helsinki
France		
11 Nov 90	Observatoire de Lyon	St. Genis Laval
11 Nov 90	Observatoire de Meudon	Meudon
11 Nov 90	Groupe d'Astrophysique de Grenoble	Grenoble
12 Nov 90	CEN-SACLAY/DPHPE/SEPH	Gif/Yvette
18 Nov 90	Observatoire de Marseille	Marseille
18 Nov 90	Observatoire de Haute-Provence	St. Michel l'Observatoire
25 Nov 90	Laboratoire d'Astronomie Spatiale	Marseille
29 Nov 90	Département d'Astrophysique Université de Nice	Nice
06 Dec 90	Petrou Service d'Astrophysique	Gif-sur-Yvette
11 Dec 90	Equipe d'Astrophysique Université Montpellier II (Sciences)	Montpellier
02 Dec 90	Centre d'Océanologie de Marseille	Marseille
13 Dec 90	Laboratoire de Cancérologie Expérimentale, Faculté de Médecine	Marseille
20 Jan 91	Institut d'Astrophysique de Paris	Paris
12 Mar 91	Observatoire de la Côte d'Azur	Nice
15 Apr 91	Observatoire Midi Pyrénées	Bagnères Bigorre
02 Jul 91	Observatoire Astronomique de Strasbourg	Strasbourg
02 Sept 91	Observatoire de Besançon	Besançon
10 Jan 91	Laboratoire de Mécanique et d'Acoustique	Marseille
03 Jul 91	LSEET, Université de Toulon	La Garde
13 Feb 92	Centre de Physique Théorique	Marseille
18 Feb 92	Centre d'Etude Spatiale des Rayonnements	Toulouse
26 Mar 92	IRAM	St.-Martin-d'Hères
Germany		
05 Nov 90	Universitäts-Sternwarte München	München
06 Nov 90	Landessternwarte Königstuhl	Heidelberg
11 Nov 90	Astronomisches Institut der Universität Tübingen	Tübingen
11 Nov 90	Institut für Astronomie und Astrophysik TU Berlin	Berlin
11 Nov 90	Dr. Remeis-Sternwarte	Bamberg
12 Nov 90	Radioastronomisches Institut der Universität Bonn	Bonn
14 Nov 90	Max-Planck-Institut für Aeronomie	Katlenburg-Lindau
25 Nov 90	Max-Planck-Institut für Extraterrestrische Physik	Garching bei München
29 Nov 90	Zentralinstitut für Astrophysik	Potsdam
02 Dec 90	Institut für Theoretische Physik und Sternwarte der Universität	Kiel
02 Dec 90	Institut für Theoretische Physik und Astrophysik	Frankfurt am Main
09 Dec 90	Max-Planck-Institut für Astrophysik	Garching bei München
20 Dec 90	Max-Planck-Institut für Extraterrestrische Physik	Garching bei München
20 Jan 91	Institut für Astronomie und Astrophysik	Würzburg
31 Jan 91	Astronomisches Institut der Ruhr-Universität Bochum	Bochum
06 Feb 91	Max-Planck-Institut für Astronomie	Heidelberg

Date	Institute	Location
27 Feb 91	Max-Planck-Institut für Radioastronomie	Bonn
03 Mar 91	Karl-Schwarzschild-Observatory (Thüringer Landessternwarte)	Tautenburg
02 Apr 91	Deutsches Museum	München
10 Apr 91	Universitäts-Sternwarte	Jena
03 Oct 91	Hamburger Sternwarte	Hamburg
17 Nov 91	Sternwarte Sonneberg	Sonneberg
21 Jan 92	Max-Planck-Institut für Kernphysik	Heidelberg
17 Jan 92	Max-Planck-Institut für Extraterrestrische Physik	Garching bei München
24 May 92	MPE-Außenstelle Berlin	Berlin
27 Oct 92	Institut für Physikalische Elektronik	Stuttgart
Greece		
29 Oct 91	Foundation for Research and Technology	Heraklion
Hungary		
02 Dec 90	Konkoly Observatory	Budapest
13 May 92	Gothard Observatory	Szombathely
Ireland		
05 Dec 90	The Dublin Institute for Advanced Studies	Dublin
17 Feb 91	University College Galway/Department of Physics	Galway
24 May 92	University College Dublin/Physics Department	Dublin
India		
09 Dec 90	Indian Institute of Astrophysics	Bangalore
13 Dec 90	Inter University Centre for Astronomy and Astrophysics	Pune
11 Jul 91	Udaipur Solar Observatory	Udaipur
27 Feb 91	U.P. State Observatory	Nainital
02 Nov 92	ISRO Satellite Centre	Bangalore
Italy		
18 Nov 90	ASTRONET Documentation Facility	Trieste
07 Jan 91	Dipartimento Scienze Fisiche	Napoli
07 Jan 91	Istituto TE.S.R.E./C.N.R.	Bologna
08 Jan 91	Istituto di Fisica Cosmica	Milano
08 Jan 91	Osservatorio Astrofisico di Arcetri	Firenze
07 Jan 91	Istituto di Fisica Cosmica e Applicazione dell Informatica/CNR	Palermo
07 Jan 91	Stazione Astronomica – Cagliari	Cagliari
28 Jan 91	Dipartimento di Fisica, Università della Cantabria	Arcavacata di Rende
20 Feb 91	Teramo Astronomical Observatory	Teramo
10 Mar 91	IFSI-CNR	Frascati, Roma
10 Mar 91	Dip. Astronomia Università di Bologna	Bologna
10 Mar 91	Cattedra di Astrofisica, Università di Perugia	Perugia
02 Apr 91	International Center for Relativistic Astrophysics	Roma
02 Apr 91	Osservatoria Astronomico di Capodimonte	Napoli
02 Apr 91	Osservatorio Astronomico di Brera	Milano
02 Apr 91	Astronomical Observatory	Monte Porzio Catone, Roma
24 Apr 91	Osservatorio Astronomico di Trieste	Trieste
24 Apr 91	Osservatorio Astronomico di Palermo	Palermo
13 May 91	Dipartimento di Fisica, Università di Milano	Milano
22 May 91	Istituto Astronomico	Roma
05 Aug 91	Osservatorio Astronomico di Padova	Padova
05 Aug 91	Osservatorio Astronomico di Torino	Pino Torinese, Torino
06 Jan 92	Scuola Normale Superiore	Pisa
30 Jan 92	SISSA	Trieste
11 May 92	Istituto Astrofisica Spaziale	Frascati
Israel		
10 Sep 91	School of Physics and Astronomy/ Tel Aviv Univ.	Ramat Aviv
Japan		
21 Oct 91	National Astronomical Observatory	Tokyo
15 Jun 92	University of Tokyo	Tokyo
Mexico		
04 Mar 91	Instituto Nacional de Astrofisica, Optica y Electrónica	Puebla
The Netherlands		
18 Nov 90	Astronomical Institute, University of Amsterdam	Amsterdam
25 Nov 90	Space Research Organization Netherlands	Utrecht
24 Jan 91	Kapteyn Astronomical Institute	Groningen
14 Apr 91	Laboratory for Space Research	Groningen
11 Jul 91	Sterrewacht Leiden	Leiden
17 Nov 91	Astronomical Institute BBL	Utrecht
05 Mar 92	ESA Astrophysics Division	Noordwijk
New Zealand		
06 Dec 90	Department of Physics University of Canterbury	Christchurch
Poland		
17 Feb 91	Astronomical Observatory of the Warsaw University	Warszawa
09 Sep 91	Institute of Astronomy/N. Copernicus University	Torun
Portugal		
24 Mar 92	Centro de Astrofisica da Universidade do Porto	Porto
Russia		
13 Jan 91	Institute of Astronomy, Russian Academy of Sciences	Moscow
Spain		
11 Nov 90	Universidad Complutense Facultad de Físicas	Madrid
25 Nov 90	Laboratori d'Astrofisica I.E.C.	Barcelona
07 Jan 91	Nordic Optical Telescope	Santa Cruz de La Palma
10 Mar 91	ESA Villafranca Satellite Tracking Station	Madrid
10 Apr 91	Dept. de Física Moderna, Facultad de Ciencias/Univ. de Cantabri	Santander
22 Apr 91	Universidad Autónoma de Madrid	Madrid
30 Oct 91	Instituto de Astrofísica de Canarias	Tenerife, Islas Canarias
04 Mar 92	Centro Astronómico de Yebes	Guadalajara
South Africa		
15 Oct 92	University of South Africa	Pretoria
Sweden		
11 Nov 90	Astronomical Observatory	Uppsala
11 Nov 90	Stockholm Observatory	Saltsjöbaden
02 Dec 90	Lund Observatory	Lund
04 Jun 91	Onsala Space Observatory	Onsala
Switzerland		
18 Nov 90	Observatoire de Genève	Sauverny
11 Jan 91	Astronomisches Institut der Universität Basel	Binningen
19 Feb 91	Institut d'Astronomie/Université de Lausanne	Chavannes-des-Bois
16 Jun 91	Institute of Astronomy ETH Zürich	Zürich
24 May 92	University of Berne/Astronomical Institute	Berne

Date	Institute	Location
Turkey		
26 May 91	Istanbul University Observatory Research Center	Istanbul
Ukraine		
28 Feb 91	Main Astronomical Observatory, Ukrainian Academy of Sciences	Kiev Goloseevo
United Kingdom		
13 Nov 90	Armagh Observatory	Armagh
19 Aug 91	Leicester University X-ray Astronomy Group	Leicester
24 May 92	University College London/Optical Science Lab.	London
20 Oct 92	Department of Astronomy/University of Manchester	Manchester
United States		
02 Dec 90	Physics Dept., University of Wisconsin	Madison
19 Apr 91	NASA/IUE Observatory	Lanham Seabrook
24 Apr 91	University of Wisconsin Astronomy Department	Madison
20 Jun 91	Smithsonian Astrophysical Observatory	Cambridge
23 Jun 91	Space Telescope Science Institute	Baltimore
29 Sep 91	University of Wisconsin/Space Physics Dept.	Madison
03 Oct 91	NASA Goddard Space Flight Center	Greenbelt
03 Oct 91	Canada-France-Hawaii-Telescope Corp.	Hawaii
17 Nov 91	University of Colorado	Boulder
31 May 92	University of Maryland	College Park
29 Juli 92	Penn State University	University Park
06 Aug 92	Naval Research Laboratory/Space Science Division	Washington
10 Nov 92	Steward Observatory	Tucson
Uruguay		
31 Mar 92	Departamento de Astronomía/ Facultad de Ciencias	Montevideo
Venezuela		
23 Oct 91	Centro de Investigaciones de Astronomía	Merida

The End of the Earth?

Titles play an important role in all areas of communication. A catching line on top of a long (and boring) text seduces the reader to have a closer look – you realize of course that that is exactly the reason why you are reading this! The boulevard press plays this game all the time, and most often you will find that the implied sensation isn't one, after all. But you spend your valuable time reading on to the end... hoping that something really interesting will show up further down the column.

Scary titles like the one above sell well nowadays. That is at least the impression we just had here at ESO, trying to answer a true deluge of questions about cosmic catastrophes. During the recent months, newspapers all over the world have been full of stories about "Lurking Danger from Space", "Giant Comet Will Collide with the Earth", "The World Ends in 2126", and the like. Solar-system astronomers from many countries have done their best to explain a frightened public about the real risks of cosmic collisions, why the dinosaurs were extinguished, how many Megatons the energy of a 1-km asteroid moving at 20 km/sec is equivalent to, how big the hole will be or what happens if it falls into the ocean, etc.

Much of this activity is the outcome of the recent announcement about the possibility that the Earth may be hit by comet P/Swift-Tuttle, which was finally recovered earlier this year after 130 years. This comet, which is named after two American astronomers who discovered it in 1862, was already seen in Beijing in 1737, and possibly even much earlier in that same country. It seems to have a rather unpredictable motion because of irregular outgassing from the cometary nucleus which causes a variable, decelerating jet-effect. This is known as the "non-gravitational force", a phenomenon that has been known since the 1820's, when it was found impossible to explain the motion of comet P/Encke by the gravitational attraction from the Sun and the planets alone.

Extrapolating the motion of P/Swift-Tuttle forwards in time, it can be seen that it will take about another 134 years before it again comes close to the Earth. According to one particular orbital prediction, and further assuming that the comet for some reason will be about 14 days late, it can be shown that it will pass very close to the Earth on August 14, 2126; a further empirical fine-tuning of the predicted orbit will actually make it collide with the Earth. The very whisper about this possibility was of course more than enough to immediately alert the media; from a vague possibility with a lot of "if's", the unavoidable took its course and in many newspapers a disastrous collision soon became the firm reality. Most of the reports of course completely failed to mention the vanishing probability of such an event – if the comet would be just a few minutes too early or too late, it would pass by without any damage, although it would still be a very spectacular sight in the sky.

Such encounters with long-period comets are much more rare than asteroid fly-bys. For instance, the one on December 8 by (4179) Toutatis was pretty close, at a distance of about 3.5 million kilometres only, and giving the astronomers a great opportunity to watch an asteroid from close quarters. Since asteroids are not plagued by non-gravitational forces (they supposedly have no ices which evaporate when they are near the sun), Toutatis' orbit can be calculated with great accuracy and there is no risk that it hits the Earth, at least this time. Still, there have been reports in the press that this will surely happen in a not too distant future.

As a solar-system astronomer, I must admit that I read such catastrophic reports with very mixed feelings. On the one hand, it gives you an impression of being a useful member of society when the media ask you to express your opinion about these events, and especially when you can put things right by referring to the extremely low probability of something disastrous happening. (You may sometimes have a brief thought about the precarious position of the astronomer-priests of earlier ages who were believed to be the masters of nature, at least until they made a wrong prediction).

On the other hand, I think that we astronomers must be extremely cautious when we deal with these matters. Even though cosmic collisions are bound to happen sooner or later, it would be very bad if we were ever suspected of deliberately creating a public scare by announcing a possible danger, just to profit by the subsequent attention of the media. We are fortunate that astronomy is reasonably free from the problems that plague some of the much more “applied” sciences – let it continue to be so!

The Editor

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

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

EUROPEAN
SOUTHERN OBSERVATORY
Karl-Schwarzschild-Str. 2
D-8046 Garching bei München
Germany
Tel. (089) 32006-0
Telex 5-28282-0 eo d
Telefax: (089) 3202362
ips@eso.org (internet)
ESOMC0::IPS (decnet)

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