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ESO Celebrates its New Technology Telescope

In the presence of a distinguished audience of ministers and high-ranking officials, as well as representatives of European industry and scientists from the member states, the European Southern Observatory officially inaugurated its revolutionary 3.5-metre New Technology Telescope (NTT) on February 6, 1990.

The festive act took place simultaneously at ESO's Headquarters in Garching near Munich, F.R. Germany, and at the La Silla Observatory in the Atacama desert, Chile. The two ESO sites, 12,000 kilometres apart, were connected with several transatlantic communication links, including a direct TV connection. This is the first time live TV images have been transmitted between ESO establishments in South America and Europe. During the ceremony, the NTT at La Silla was remotely controlled from Europe.

The NTT inauguration was well reported in the international press, and also in the TV evening news in various ESO member countries and in Chile. Bavarian television devoted the entire 30-minute "Abendschau" on this day to ESO and its new telescope.

The texts of the official speeches are brought in this Messenger issue on page 6ff.

The Programme in Europe

At the ESO Headquarters, the day started with a press conference which was attended by about 50 media representatives from all over Europe. A comprehensive press kit had been prepared, including the new NTT brochure, technical fact sheets and photos of the NTT as well as more than two dozen astronomical images recently obtained with the new instrument.

On the European side, the inaugural ceremony took place in the ESO Auditorium under the watchful cameras of five national TV companies and in the presence of representatives of most major newspapers and news agencies in the ESO member countries.

The solemn event was officially opened by Professor Harry van der Laan, ESO Director General, who welcomed the guests and briefly outlined the importance of the NTT. He was followed by Dr. Raymond Wilson, ESO Senior Optical Scientist and father of the

At the Press Conference in Garching. From left to right: Manfred Ziebell, Daniel Enard, Raymond Wilson, Harry van der Laan, Massimo Tarenghi. The photos accompanying this report about the NTT inauguration were obtained by ESO photographers J. Quebatte and H.-H. Heyer (Garching) and by the newspaper "El Día" (La Silla).

The international press in Garching.

revolutionary "active optics" concept, now incorporated into the NTT. Professor Massimo Tarenghi, Manager of the NTT project, spoke about the first, extremely promising astronomical results from the NTT and stressed the crucial role played by European industry in this high-tech venture.

Then a 25-minute BBC-made film about ESO was shown for the first time. The producers, Peter Mopurgo and Patrick Moore from the "Sky at Night" programme, both present in the auditorium, received a hearty applause for their excellent work.

In the subsequent address, Professor Per-Olof Lindblad, President of the ESO Council, stressed the important interplay between astronomy and technology and the need to provide the very best. The NTT is a great gift to European astronomy.

At this moment, the first live TV images from La Silla could be seen on the screen in Garching. After transmitting a panorama of the mountain, the camera from Chile's Televisión Nacional focussed on the NTT building and the assembled guests under the sun shade. On behalf on the observatory staff, Daniel Hofstadt, Chairman of the La Silla Management Team, recapitulated the developments which have now led to the installation at La Silla of the technologically most advanced optical telescope in the world.

From the ESO Headquarters in Garching, Professor Antonio Ruberti, Italian Minister of University, Scientific and Technological Research, now addressed the audience on both sides of the ocean. He mentioned the essential contribution of his country to the NTT project and the enthusiasm of participating Italian industries. Pushing a button on the control terminal installed in the Auditorium for this purpose, the Minister then rotated the NTT building; this could be followed live on the TV screens.

Patrick Moore from the BBC.

The next speaker was Ambassador Jean-Pierre Keusch, Director of the Directorate of International Organizations, Bern, Switzerland. Although he "felt a slight disappointment not to be physically at La Silla", he was fascinated by the possibilities of remote control and thought that the Swiss entrance fee to ESO had been well spent. The Ambassador opened the NTT doors with a push of a button.

Dr. Heinz Riesenhuber, German Federal Minister of Research and Technology, saw the NTT as the latest achievement in a long chain of advances in astronomical technology, reaching all the way back to Stonehenge. It is also a "financial masterpiece", having stayed well within the originally foreseen budget. Expressing the hope that this would also be the case for ESO's next project, the Very Large Telescope, the Minister sent a command to the NTT which was soon seen to move obligingly towards a horizontal position.

At this moment, Monsignor Cox, Coadjutor Archbishop of La Serena – the capital of the IVth Region in Chile, in which La Silla is located – pronounced a blessing of the new instrument. Hereafter, the ESO Director General declared the NTT officially inaugurated.

Professor Hubert Curien, French Minister of Science and Technology, added his appreciation of ESO "as one of the most interesting European organizations" and underlined the paramount im-

In the Auditorium: Former ESO Director General Adriaan Blaauw, between delegates Mats Ottosson (S) and Peter Creola (CH).

There were many known faces in the ESO Auditorium.

and G. Tammann (Basel, Switzerland). They all stressed the NTT's great observational possibilities in various astronomical fields of particular actuality.

Events in Chile

In Chile, the inaugural events commenced with dinners in La Serena and at the La Silla Observatory during the evening of February 5. Many distinguished guests had come from Santiago and La Serena, including most of the Ambassadors of the ESO member states and many official representatives of Chilean institutions and organizations. The Chilean media were well represented and reported widely about the NTT and ESO, also during the days before.

In the morning of February 6, the guests and ESO staff members

From left to right: Ambassador Keusch (CH), Minister Riesenhuber (D), Minister Curien (F), Minister Tobback (B).

portance of European collaboration in all fields. Astronomy may serve as a good example.

A short video film with a summary of the most recent astronomical images from the NTT and their scientific significance was then shown. It was based on CCD images obtained by ESO staff astronomers towards the end of the commissioning phase in December 1989 – January 1990 and had been prepared by the ESO Information Service during the days (and nights) preceding the inauguration.

At the end of the official programme, two ESO staff members who have carried a particularly large measure of responsibility for the success of the NTT project were honoured in a brief ceremony. Massimo Tarenghi was elevated to the rank of "Commendatore dell'Ordine al Merito della Repubblica Italiana" by Minister Ruberti, and Raymond Wilson received the "Medal of the University of Geneva" with accompanying descriptive scroll from the hands of Professor Marcel Golay, Director of the Geneva Observatory. As a token of gratitude for cheerful support to their busy husbands throughout the long years of the NTT project, the Director General presented Mrs. Tarenghi and Wilson with flowers.

After a break for refreshments, a scientific session followed with talks by three distinguished European astrophysicists, Professors G. Miley (Leiden, the Netherlands), F. Pacini (Florence, Italy)

A happy moment.

Massimo Tarenghi receives an order from Minister Ruberti.

Raymond Wilson thanks Marcel Golay.

Minister Riesenhuber and the ESO Director General are interviewed by Bavarian Television.

gathered under a sunshade in front of the NTT building. The simultaneous proceedings in Europe could be followed via an audio link during part of the ceremony. Unfortunately, this link broke down towards the end, but a running commentary was provided to the guests instead.

It was also possible to transmit TV pictures at a slow rate through the new 64 kbaud digital link from Garching to La Silla.

The guests at La Silla experienced the remote control commands from Europe at close quarters and, after the ceremony, were able to visit the NTT building under the guidance of ESO engineers and astronomers.

The New Technology Telescope

The centre of attention on this memorable day, the ESO 3.5-m New Technology Telescope, is an astronomi-

George Miley talks about distant objects and early times. To the left former ESO Director General Lo Woltjer.

Franco Pacini reveals the secrets of supernovae.

Gustav Tammann discusses the distance scale and other observational facts.

cal instrument for the 21st century and incorporates many new technologies, in particular within optics, mechanics and electronics. Moreover, the NTT building has been especially conceived to ensure a minimal influence on the observations.

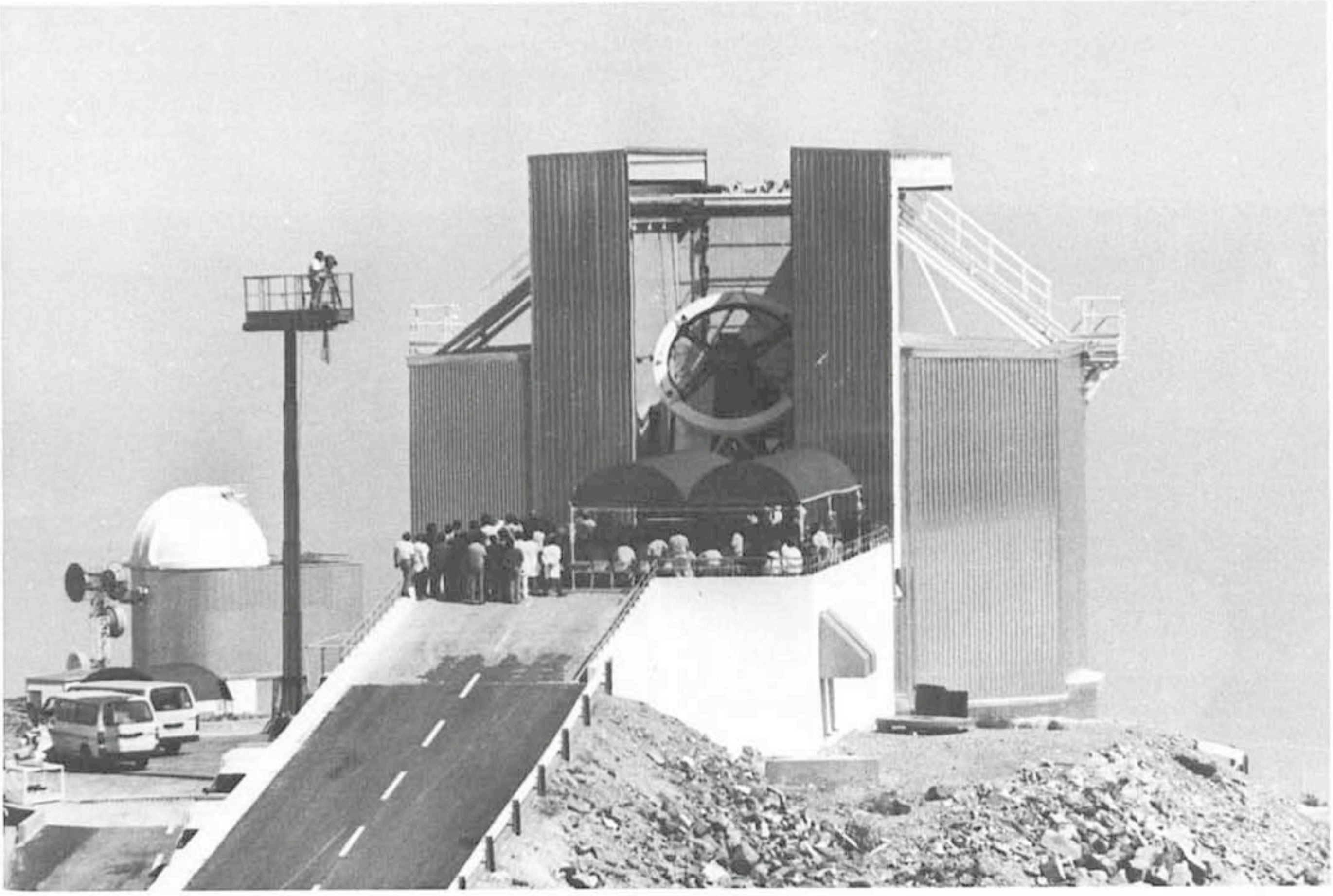
Already during the night of "first light" (cf. *Messenger* **56,** p. 1), the 24 million DM (14 million US $) NTT has demonstrated its enormous observational possibilities. In the meantime, this has been fully confirmed by a great variety of astronomical observations, carried out by ESO staff astronomers in the course of the start-up phase. A small gallery of recent astronomical images from the NTT is shown on page 14ff.

Unprecedentedly sharp images have been obtained (down to 0.33 arcseconds FWHM) and extremely faint objects have been recorded (under seeing conditions not unusual at La Silla, stars near 26th magnitude are registered in 15-minute CCD exposures; this corresponds to magnitude 27 in one hour). For more information about the new CCD detectors, now in use at the NTT, the reader is referred to the article by S. D'Odorico on page 59.

This indicates that, in the optical region of the spectrum, the NTT achieves a spatial resolution only three times worse than that predicted for the Hubble Space Telescope (which is now expected to be launched in mid-April 1990). The introduction of adaptive techniques at the NTT (cf. *Messenger* **58,** p. 1) may further reduce this gap during the next years. The limiting magnitude of the two telescopes in the optical region is about equal.

The first visiting astronomers from ESO member countries to the NTT were received at La Silla on January 17, 1990. The first programme was dedicated to Supernova 1987A in the Large Magellanic Cloud.

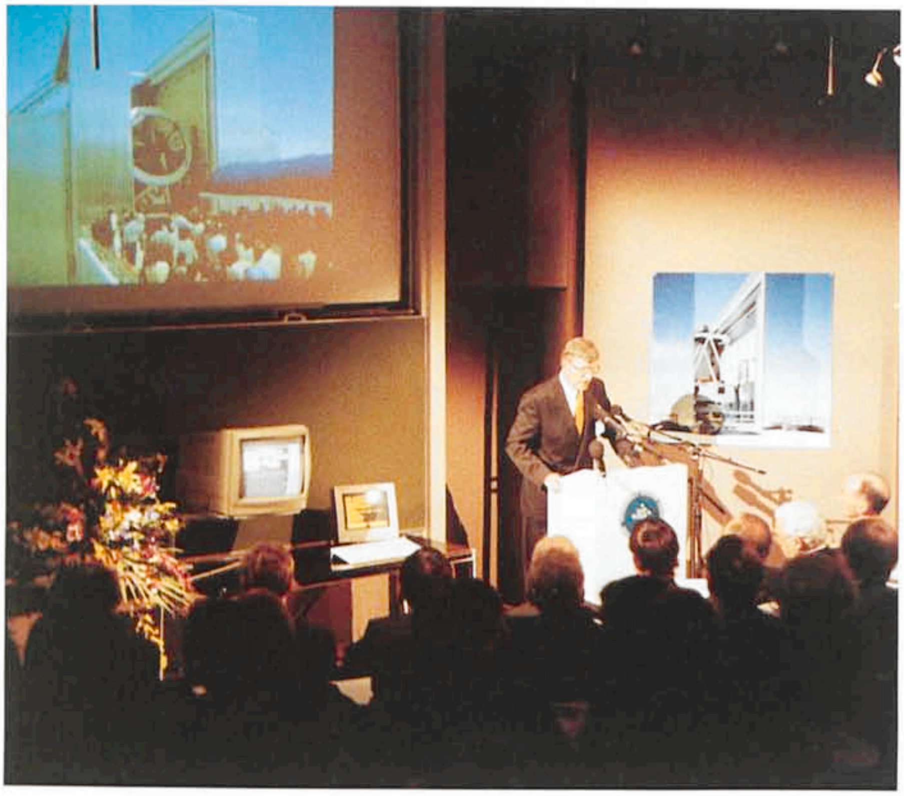
The NTT, while an excellent telescope in its own right, is also the forerunner of ESO's next telescope project, the 16-metre Very Large Telescope, which is expected to be ready in 1999. Consisting of four 8.2-metre telescopes, it will become the largest ground-based telescope in the world. *The Editor*



Official guests at La Silla.

Official Speeches at the NTT Inauguration

Prof. H. VAN DER LAAN, ESO's Director General



Your Excellencies, Honoured Guests, Ladies and Gentlemen,

To welcome all of you, in ESO Headquarters *and* on our La Silla Observatory in Chile, to this festive dedication of our New Technology Telescope, is a pleasure and a privilege. This is *one* event on *two* continents, ESO's two major sites connected by several electronic communication links, ESO's guests and ESO staff present and participating on a wintry afternoon in Bavaria and on a sunny summer morning at 2400 m, high in the beauty of the Atacama desert. We hope that technology will not fail us now, but if it does and we cannot hear and see each other, then still it will be a *celebration, in two simultaneous* parts, by people linked by their engagement for astronomical exploration.

ESO, a small but not *un*interesting European Organization, has since its founding 27 years ago, been enriched by three new member states, Denmark, Italy and Switzerland. The latter two nations, for now the latest members of this 8 European nation astronomy chain, obtained the green light for their accession with a Council decision on 26 March 1980, effected in the course of 1982. In that same Council meeting it was decided that the entrance fee to be paid by the new members in accordance with the ESO Convention, would be used for the construction of a telescope of 3.5 m aperture, exploiting the newest technologies. Note that this imaginative project could only be realized because all member states agreed not to profit from this entrance fee to reduce their own contributions . . . Thus it became possible to enhance ESO's capacity in the form of total telescope time offered, through an addition to its suite of telescopes, an enhancement required by the enlargement, by about 25%, of the ESO user community.

From *that* set of decisions to this day, a lengthy path had to be travelled, often in the literal sense of the term, which took many ESO staff members to industries throughout Europe and frequently to our observatory in Chile. This path required persistence and patience, from the staff and from their spouses and families, in order for this common effort to achieve the communal success which today we celebrate jointly.

The New Technology Telescope, equipped with active optics, precision large scale mechanics, housed in a cleverly different, octagonal building (named corn silo by some . . .) and able to be controlled remotely from Europe, bears its prosaic name with good reason. It is already now the centre of envious attention. With two press releases and several descriptive articles in our journal *The Messenger,* it has attained popularity far beyond our member states, with a number of more or less identical twins being spawned with highest priority in astronomers' plans for the future elsewhere.

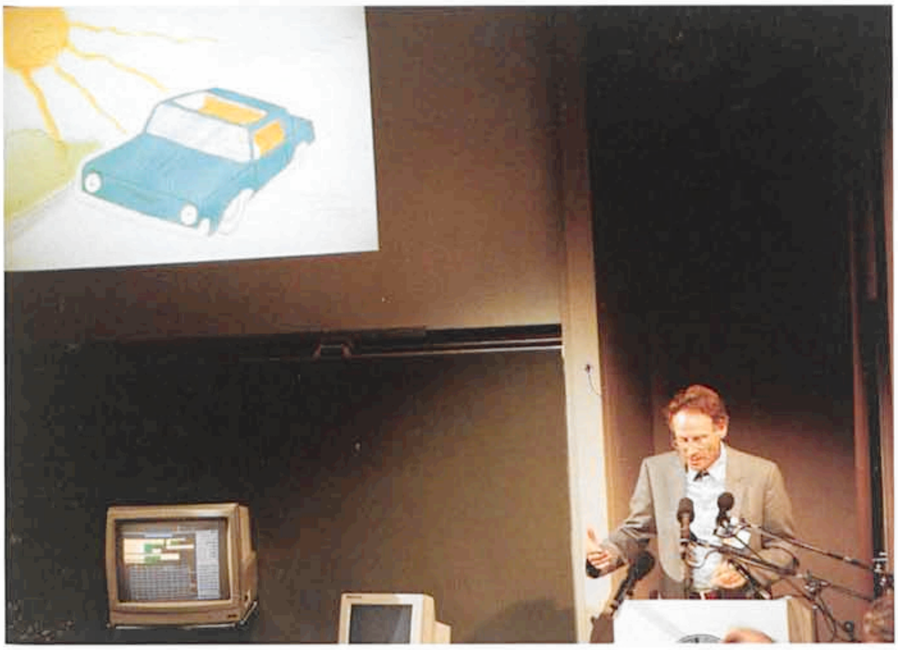
Just to be sure that in, say, five years the NTT will not be an *Old* Technology Telescope, we intend to equip it with *adaptive optics,* exploiting its superb optics and its marvelously low 'dome seeing' and then to attain image sharpness only thought possible for space telescopes one hundred times as expensive as the NTT.

The designation 'New Technology Telescope' is warranted by the innovations to which I have alluded and of course the creativity, improvization, collaboration and *esprit de corps* achieved by ESO staff in Europe and in Chile and by our industry partners. A complex facility like the NTT is, to begin with, necessarily full of problems and faults, infant's teething troubles. The community astronomers keenly competing to get their hands on this exciting machine for their ambitious research goals, will need patience and tolerance as we perfect this telescope in practice, the telescope which on the cover of the American journal *Sky & Telescope* was named 'the best telescope yet' . . .

The NTT is the result of many talented people's cumulative efforts. I can name but three of them: my predecessor Lodewijk Woltjer, who guided the decision-making and guarded the telescope's relative simplicity, Raymond Wilson, whose creative development of active optics concepts was followed by the careful nitty gritty of implementing concepts into real life systems that work, and last but not least, Massimo Tarenghi who transformed his astronomer self into project scientist, project manager and project engineer rolled into one. His dedication to the NTT, his fondness for his team and his love of astronomy brought it all to this happy climax.

The European House of Astronomy, blessed by the riches of both hemispheres' starry heavens, is today the better equipped for our exploration. May the creative innovation which the NTT represents, inspire the ambitious collaborations which make this house such a fascinating abode.

Dr. R. N. WILSON, ESO Senior Optical Scientist



Ladies and Gentlemen,

In my brief talk today, I shall limit myself to the single point *"IMAGE QUALITY"*, but we should not forget that many forefront technologies are involved in the other vital aspects of the telescope (e.g. tracking, pointing, remote control). However, the image quality aspect is that where the NTT is *unique* and, we believe, a milestone in telescope development.

There are three factors which have led to the remarkable image quality of the NTT:

(1) The concept of *"active optics"*
(2) The *figuring quality* for 3 mirrors achieved by Carl Zeiss based on the active optics concept
(3) The *building* concept around the *ALT-AZ mounting*, which maintains optimum conditions of the local air.

1. Active Optics concept

This is a perfectly classical *feedback control system*. It looks like this. A star image in the field of the telescope is fed into the *image analyser* (upper box), its results then processed in the microcomputer (lower box) which sends signals to control the position of the secondary mirror and also to the supports of the primary mirror. The key element is the on-line *image-analyser* which, with the micro-computer, defines the image properties which have to be optimized: *only that which can be measured can be optimized* (a basic principle of feedback control). The image analyser is the *brain* of the telescope which enables it *to maintain itself "actively"*. In contrast, a normal "passive" telescope has no brain: it has to be maintained by difficult, off-line interventions.

2. Figuring of the NTT optics by Carl Zeiss, Oberkochen

One of the two principal advantages of the active optics concept is that certain optical manufacturing tolerances can be relaxed. This enables the manufacturer to concentrate on achieving, in the technical optical sense, the extremely "smooth" surfaces necessary for the exceptional image quality of the NTT.

To realize this, the manufacturers have developed a technology, both for testing and for figuring, which is unsurpassed in the entire world. Here is a view of the primary mirror of the NTT, in its final cell placed on the turntable of the figuring machine, as set up for the final tests. I should like you to note that the mirror blank, of superb quality manufactured by Schott of Mainz, is relatively thin, another important consequence of active optics.

3. The building concept

The total airpath from the telescope to the top of the atmosphere is part of the optical system. The "local" part near the telescope is influenced by the telescope itself, the building with its facilities and nearby site conditions. In classical telescopes with big domes, the influence on the local air has often been very negative, sometimes the worst optical effect altogether.

Let me show you with a simple analogy, as drawn by my colleague Ed Janssen, the fundamental characteristic of the NTT building which enables it to maintain vastly improved conditions of the local air.

You see here a situation which is very common for me on a hot summer's day when I get into my car on the ESO parking lot. Both myself and the car suffer acutely from the heat. So I first open the left-hand window. But this does little good: the hot air cannot escape. Then I open a fairly narrow slit in the roof, a situation already more favourable than most classical domes. But the air still cannot circulate effectively. The next stage is to open the roof fully. This brings a big improvement and both I and the car feel much better. But the last stage goes further and represents the equivalent of the NTT building: I have opened also the right-hand window, giving a through draught and full upward convection. I and the car are happy.

Now here, in comparison, is the NTT building, manufactured by the Italian firm Mecnafer, in its most open state for optimum natural ventilation: vertical walls, completely open at the top, completely open on *both* sides, although you cannot see from the slide that the back wall can also effectively be fully open.

A final word about the figure in green overalls in the foreground. This is my friend and colleague Francis Franza, without whose fundamental contribution throughout the project we would not be celebrating this inauguration today. I wish also to express my deepest thanks to many other colleagues for their major contributions.

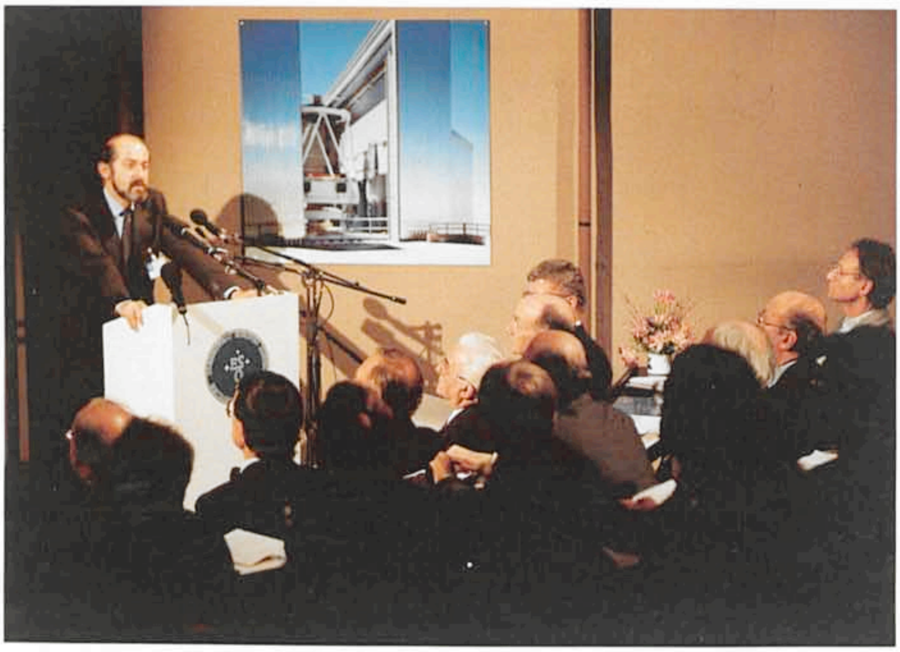
Prof. M. TARENGHI, ESO NTT Project Manager

Ladies and Gentlemen,

For the past 6 years I have had to act fast and be on time as Manager of the NTT Project. Today is no exception.

The NTT adventure began in 1982 with the entry of Italy and Switzerland into ESO.

At that time it was decided to build the NTT, a telescope of 3.5 m aperture with improved performances, able to obtain the best possible images from Earth. All



The first results have surpassed even the great expectations we had at the beginning of the Project.

What counts is not only the perfection of the optics and mechanics but the unit design of the whole system, the combination of the rotating building and telescope in one machine able to produce the best possible pictures of the sky.

The NTT has opened up new observational frontiers for astronomers and it has significantly narrowed the gap between the potential of ground-based telescopes and the Space Telescope.

European industry has shown great competence in building such a large, sophisticated and sensitive instrument. I would like to give my sincere thanks to them for their hard work and commitment.

Finally I would like to thank all my colleagues with whom I shared moments of expectation, difficulties, enthusiasm, even panic, and great satisfaction.

It is this group of active people who have invented the first active telescope in the world: the NTT.

this with a budget of only 24 million DM, less than one third of the cost of a conventional 4-metre-class telescope such as the ESO 3.6-m.

The difference in concept and shape between the old and new ESO telescopes is evident in this drawing.

Now you can see how they look in reality on La Silla.

Many years of experience accumulated by ESO running the La Silla telescopes combined with the experience of many other observatories and enriched by the exploitation of new technologies have guided the NTT concept and realization.

Time does not allow me to describe at length the NTT characteristics, new ideas and solutions utilized in the optics, mechanics, building and computer control.

Now that the telescope has been integrated into its rotating building it is not entirely visible. Only at the time of the erection in Europe at INNSE (Italy) was it possible to admire the complete structure.

Even more difficult to see are three of the major technological features of the NTT Project:

- the hydrostatic bearing system which supports the 110 tons of the telescope on a thin film of oil which is thermally controlled;
- the large and very accurate roller bearing supporting the rotating 250 ton building;
- the 78 active supports in the primary mirror cell.

It is important to remember that already on the occasion of the "first light" on 23 March 1989, remote control was used to receive images in Garching via satellite. Remote control from Europe will become a routine procedure with the NTT Telescope.

Prof. P. O. LINDBLAD, President of the ESO Council

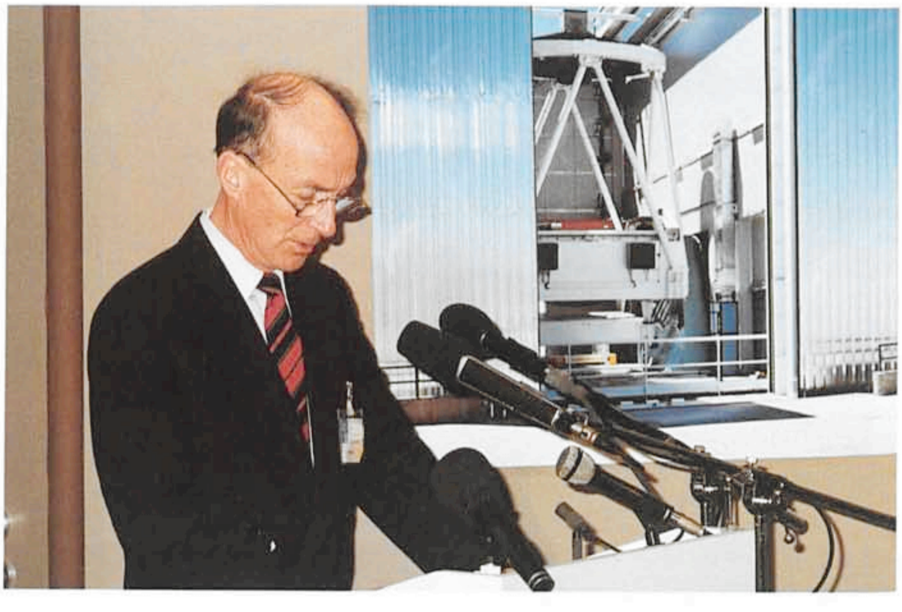
Your Excellencies, Honoured Guests, Dear Friends and Colleagues,

Astronomy is, as the Finnish philosopher George Henri V. von Wright would classify it, an epistemic science – the motive force of its scientific enterprise is the strive for knowledge, the urge of man to find out, for himself and independently of being told, how things are – about the universe in which he lives. Its basic psychological drive is curiosity.

The final product of our efforts as astronomers, we think, is of benefit to mankind, but in a form that cannot be expressed in economic value or profit.

To convince our supporting governments that their money is well spent, do we have any other way than to – perhaps naively said – provide the very best.

The aim of astronomy is not to advance technology. However, to provide the very best, astronomers need the most advanced technology available.



Because of the unique and often very extreme requirements put by astronomy, astronomy has often been the driving force and inspiration to push technology to its very limits.

This is why this New Technology Telescope is such an important tool, not only to pursue the final aim of astronomy, but also to be a test bed for development of technology for our next big project, the Very Large Telescope.

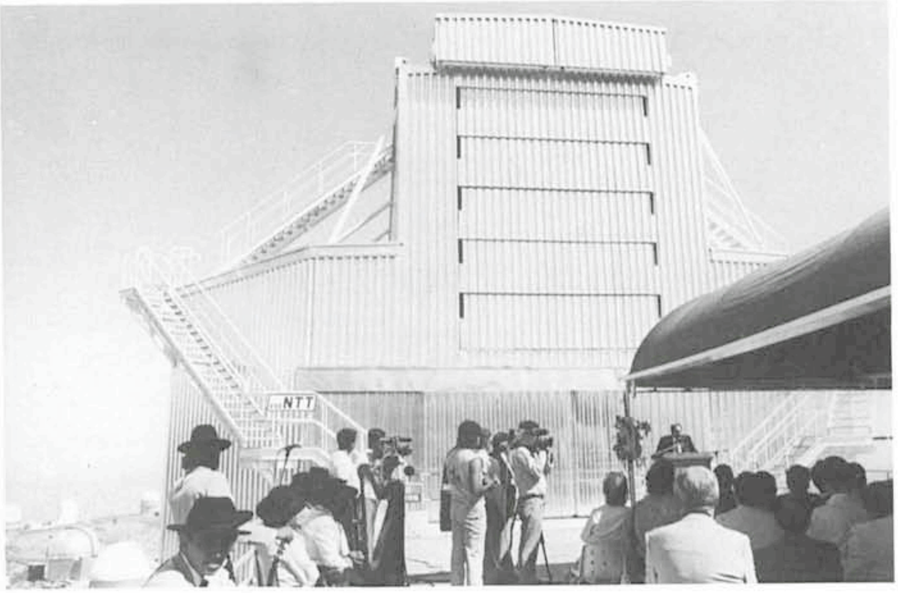
Without European collaboration and generous support by our governments the very impressive constructions in the remote mountain desert of Chile could not have been achieved. This collaboration has been of fundamental importance for the advanced position of European astronomy today.

Modern communication systems tie together the centres of our Organization. The same technique that allows us to inaugurate this new telescope simultaneously on La Silla and in Garching, however, deprives us of a good excuse to visit the beautiful country of Chile and its charming people – to enjoy the dark, brilliant starry sky of La Silla and the wonder of the central Milky Way pass over your head through the zenith.

The entrance contributions of Italy and Switzerland made the New Technology Telescope possible. Thanks to the forsight of the former Director General, Professor Woltjer, and to the ingenuity and dedication of Professor Tarenghi, Dr. Wilson and other ESO staff in Europe and Chile, as well as the skill of European industry.

This telescope, whose construction rests on the most advanced knowledge and technique, is given to European astronomers whose responsibilities it is – from now on – to use this telescope to provide – the very best.

D. HOFSTADT, Chairman of Management Team, La Silla Observatory



Your Excellencies, Honoured Guests, Ladies and Gentlemen:

Bienvenidos. Welcome to La Silla.

Twenty-five years ago La Silla was but one more mountain in this desert.

At the time scientists in Europe were planning an international observatory in the southern hemisphere. The idea was to promote European astronomy with advanced observing facilities in a site where the Magellanic Clouds, our galactic centre and other targets of great astrophysical interest could be observed.

Chile had welcomed our young organization with a Convention signed in 1963 and offered the exceptional sky transparency at the edge of its Atacama desert. Soon thereafter, this mountain was chosen and a base camp installed in the valley. Activity began – first on horse back, later by road and trucks.

It was largely thanks to French assistance that our first telescopes came to light. The Grand Prism Objective, our Galileo-type telescope came first. Soon to be followed by a 1-m, a 1.52-m aperture telescope and a set of four (4) smaller photometric units on the platform below.

Part of the original ESO agreement considered a highly detailed and deep sky survey. It was initiated in 1972 with a Schmidt telescope designed and constructed in Hamburg. By now two major atlases at different wavelengths have been completed and are used worldwide as reference maps for the southern skies.

But the most important observing facility was still to come. In 1976 our largest telescope, the 3.6-m began its scientific life. Through the years it has acquired an unparalleled set of instruments, detectors, configuration options which stimulated a vast number of scientific programmes. It also provided us with a reasonable amount of headaches . . .

The appendix tower on the western side contains yet another technological challenge: an innovative telescope which is connected with a highly efficient spectrograph located in the main building, a powerful and unique tool for high-dispersion spectroscopic work.

As our organization was growing, two institutes in Europe, the Copenhagen University and the Max-Planck-Gesellschaft in Germany entrusted us their instruments. A 1.5-m and a 2.2-m telescope found their home base at La Silla. The same occurred recently through collaboration with the University of Gothenburg in Sweden when we brought the largest sub-mm telescope, south of the equator, into operation, thus extending our observing bandwidth capacity to the longer wavelengths.

Meanwhile our Italian and Swiss colleagues maintained a keen interest in our evolution and realized that La Silla had still some space for . . . another telescope. In 1982 these two countries formally joined our adventure adding new resources and ambitions which have materialized now into the New Technology Telescope in front of us.

New technology in the domain of optics, structures and communications had been tested and was not unfamiliar to our staff. Clearly, the time had come to cristallize our ideas and courage into a different challenge. And today we are about to turn over to the scientific community a truly exceptional tool to reach a deeper grasp into the universe.

But maybe the most important aspect of our brief history is that our observatory has developed its own soul. Through a quarter century we have learned and consolidated our own road to the challenge of the future.

I wish to end by thanking all my colleagues who have worked and sweated for the success of our enterprise, sometimes with great sacrifices. I can promise that much more sweat and work will be required to demonstrate that what we are claiming will become true.

Prof. A. RUBERTI, Minister of University, Scientific and Technological Research, Italy

Distinguished Colleagues, Mr. Director General, Ladies and Gentlemen,

It was with great pleasure that I accepted the Organization's kind invitation to be present here today, on the occasion of the opening ceremony of the NTT telescope. A telescope that, with its innovative conception represents the first operational application of the new technologies developed by the European astronomical scientific community with the contribution of the industrial sector.

Today's event has a particular meaning for Italy. The approval of this project has been promoted with great determination by my Government. By entering ESO, Italy has intended to give an essential contribution to the construction of the NTT. Our researchers, first of all Professor Tarenghi, the Project Manager, and our industries have accepted with enthusiasm the invitation to collaborate.

This support, which was already unreservedly expressed in the past, has been confirmed by my Government also for the future.

Along the developing line of the NTT, it has been recently decided to start an even more ambitious project, aimed at providing the European astronomers with an optical observation instrument which will be one of the most powerful in the world: the VLT, for the construction of which the experience and the results of the NTT, starting its operative life officially today, will be invaluable. This was also a decision supported with resolution by my Government; I remember that my predecessor was the first, among the Research Ministers of the Member States, to publicly express a favourable opinion of this project on the occasion of a congress held in Venice.

We supported the VLT at that time and we still support it today because Italy firmly believes in the value of the international scientific cooperation, particularly because we wish to best contribute to enable ESO to maintain the pre-eminent role it has reached in the world today. The policy of our Government and of our researchers shall always aim at eliminating obstacles coming between the reaching of such a goal and at letting the possible problems find a positive solution to enable a satisfactory course of the project and of the organization in its entity.

The development of a broader and broader international cooperation is one of our priorities and we intend to give it a significant contribution, strengthening, at the same time, national programmes.

This is therefore the clue to interpret our firm support for ESO's development. We still intend to guarantee, on the one hand, our support in the future to ESO, and on the other hand, to favour the launch of great national initiatives, such as:

- the project of building a second supertelescope, the Columbus, which is going to be placed in the northern hemisphere and which will thus be a complement of the VLT;
- the construction of the national telescope Galileo, with a diameter of 3.5 metres for which project the technologies set up for the NTT will be made available.
- the further development of the VLBI European network with the antennae of Bologna and Noto and, possibly, even others.
- the close scientific and technological cooperation between earth and space astronomy.

On closing this address, and confirming once again Italy's full satisfaction with the results obtained, I wish to express, Mr. Director General, my sincere thanks to all who contributed to the success of the initiative with their efficient work and especially:

- to Professor Woltjer, who preceded you, for taking the Organization to the vanguard of world astronomical studies and for having wanted and almost brought to its conclusion the NTT and for having contributed in a resolute way in the early 80's to our decision to enter ESO.
- to you, Professor van der Laan, for having taken over with equal enthusiasm the spirit of Professor Woltjer's work and for all that will be done in the future to maintain the level of excellence of the Organization, fostering the general agreement of objectives which is absolutely necessary.
- to Professor Tarenghi and the entire staff, particularly to Dr. Wilson, responsible for the optics, for having made the building of the NTT, with their daily efforts, possible.

I am thoroughly convinced, Mr. Director General, that thanks to the efforts made up to now, by your managers and by all researchers, ESO has now reached its full scientific and technological development which enables us today to look with optimism at more ambitious future goals.

To the benefit of all the European scientific community, I give thus all researchers and all those who are involved in the activities of ESO my best wishes for their future work and for further significant success like the one we have seen today.

Ambassador J.-P. KEUSCH, Director of the Directorate of International Organizations, Bern, Switzerland

Your Excellencies, Director General, Ladies and Gentlemen,

The inauguration of ESO's New Technology Telescope is a very special event in the history of European scientific and technological cooperation. It is therefore with great pleasure that I participate in these celebrations. Let me first convey to you the greetings of the Swiss Government and in particular of our foreign minister, Mr. René Felbert, who was unfortunately not able to attend.

Compared to ESA, the European Southern Observatory is small in terms of its budget and number of persons, but the events we are watching and indeed participating in are proof that a successful scientific endeavour, even in our times, must not necessarily cost billions. Not only are we inaugurating today the world's most modern and most performing optical telescope, we are also writing technological history by operating this instrument, high on a mountain top on the other side of the world, by remote control via satellite from here at Garching.

For some of us, it might be perhaps just a little disappointing not to be physically at La Silla, not to have the material feeling of what we have built together. To me, I must admit, this is quite fascinating. We have watched Minister Ruberti actually operating the telescope and we have seen on this screen how his command was diligently executed. What a spectacular change to the decision-making and executing process we are accustomed to, where long chains of commands and elaborate organizational structures usually prevent us from actually seeing happen what we want to realize! Here we see in real time and I am looking forward to my turn in a minute for pushing this button.

But let me briefly turn back to the history of the NTT. When Switzerland took the decision to join ESO at a late stage, almost 20 years after the entering into force of its Convention, it could have been interpreted as a lack of interest and collaboration spirit in the frame of European scientific and technological integration. Reality was somewhat more complex, but today we see a positive aspect of our delayed entry.

Because we joined late we had to pay the handsome sum of DM 6 million as an entry fee and it became available immediately. Together with the even more substantial Italian contribution, it has been a decisive element for ESO. All this money went into the construction of this beautiful new telescope. I dare say it would not have been constructed so rapidly if it had had to go through the normal budgetary processes. The Italian and Swiss entry fees have been transformed into this splendid example of scientific ingenuity and technological innovation.

With the commissioning of the NTT, its exciting career as one of the world's outstanding scientific instruments now officially begins.

The other key role of our new telescope is of course that of a technological predecessor to the Very Large Telescope (VLT), decided by the Member States in December 1987. This time there is not such a special contribution. ESO's budget will have to be increased considerably, but I am confident that Member States will honour their commitment and that the Executive, building on its experience with the NTT, will cope successfully with this new challenge.

Let me conclude by extending the Swiss Government's most hearty congratulations to the European Southern Observatory and to its brand new and shining telescope. In pushing this button, I would like to wish it all the best for a long and brilliant career.

Dr. H. RIESENHUBER, Federal Minister of Research and Technology, Bonn, F.R. Germany

Meine sehr geehrten Damen und Herren, als deutscher Minister begrüße ich Sie besonders gern in deutsch.

Pero al mismo tiempo quiero saludar a las Excelencias y a nuestros amigos en La Silla que han contribuido tanto durante los últimos años para el éxito de nuestro trabajo aquí.

Knowing that I have to submit myself to the lingua franca of ESO – during the past 27 years it was English – I herewith wish to welcome all of you very heartily, especially our new partners from Switzerland, from Italy, Prof. Ruberti, Botschafter Keusch, who have contributed to the success of this work, not only by pushing the button in such a brilliant way, but by joining this common effort as good partners on a long way which we will continue to walk together.

Astronomy is the oldest science we have got. From the stones of Stonehenge to the lenses of an NTT was a very long way, but what was the driving power over these years was the curiosity of mankind to discover what is

behind it all, what we can understand, to see the changes of the unchanging, and to find out which new instruments we must erect in order to understand what we have not yet found.

On this long road, NTT is the most elaborate and the most modern instrument we have worldwide. It has been shown in the way the new technologies have been implemented, it has been shown in the way we have used the most modern devices of micro-electronics, of control, of new equipment-sharing systems. This all has led to a unique instrument for our science. It is a technical masterpiece. It has already shown what it can do. But let me state that it is a financial masterpiece as well. Not only because it costs one third of the last generation of telescopes with the same mirror diameter, but also because ESO managed to stick to time schedules and cost schedules and this is an extremely important thing.

It has been stated that we are now embarking on a new generation of telescopes with the Very Large Telescope project. This is a challenge. A large telescope, a very costly telescope, and we have to cooperate with each other so that it will be a success. It will be a challenge for the management. ESO has decided not to use a prime contractor, to do on its own responsibility this job. This means that in the forthcoming years, all efforts must be directed to this very subject. The challenge is also a financial one and I am looking very much forward that, in the same way as it has just been shown, ESO will stick to schedules for the VLT, time-wise and money-wise.

I will not comment in detail the technical achievements we have in front of us, the combination of large-scale optics, of sensor and control technologies, of micro-electronics, of new manufacturing and measuring systems. This has been important, not only for this telescope, but also for a new generation of engineers as well. I do think that our industries will make excellent use of these new possibilities.

Ladies and Gentlemen, what we are inaugurating now is a new instrument for the science. During the past years, young scientists have become accustomed to cooperate with the best possible instruments and in the best possible spirit. This is also the task of the future. I think that we must all get used to understand that jointly we can achieve goals that are beyond the reach of any single nation: in basic research, in coping with the problems of the environment, in new and very large technologies. I believe that what we have here is a piece of equipment that demonstrates the importance of applying excellent instruments to pure science. This is a challenge for the young generation which gets together in joint efforts that are always above the possibilities of individual countries.

In this spirit I wish a good success to NTT, to the coming VLT, to the spirit of our scientific community, and to the integration of all our scientific nations into one world-wide community. May they successfully climb the steep path into the future!

Monsignor COX, Coadjutor Archbishop of La Serena

Dear Brothers,

The brotherly cooperation of people, institutions and countries has made possible the installation of this new telescope, a wonder of modern technology. With it, scientists will explore space and heavenly bodies and we will be able to know better and admire better the universe in which we live.

Its immensity astounds us and will always be the object of scientific investigations, but the human spirit will also search for the origin and the sense of everything which exists. This cannot be answered, not even by the most perfect scientific instrument. It is the domaine of philosophy and, in the last instance, of faith.

Let us listen because of this with humble respect to the words of the holy scriptures in the first chapter of the book of Genesis:

"In the beginning God created Heaven and Earth. And the Earth was void and empty and darkness was on the face of the deep. And the spirit of God moved over the waters and God said 'let there be light'. And light was made and God saw that the light was good."

And with our thoughts in God, let us ask for his blessing so that the use of this telescope will always be for the service of peace, for the real good of man and honour of our Creator.

Benedictio deo omnipotentis. Patris et filii et spiritus sancti descenda su per hoc instrumento et superomnis qui cum colaborant et maniat semper.

In nomina patris et filii et spiritus sancti, Amen.

Prof. H. CURIEN, Minister of Science and Technology, Paris, France

Messieurs, Collègues!

Après le geste symbolique et très émouvant de Monseigneur l'Archevêque de La Serena, j'ai le devoir un peu ingrat de vous ramener du ciel vers la terre.

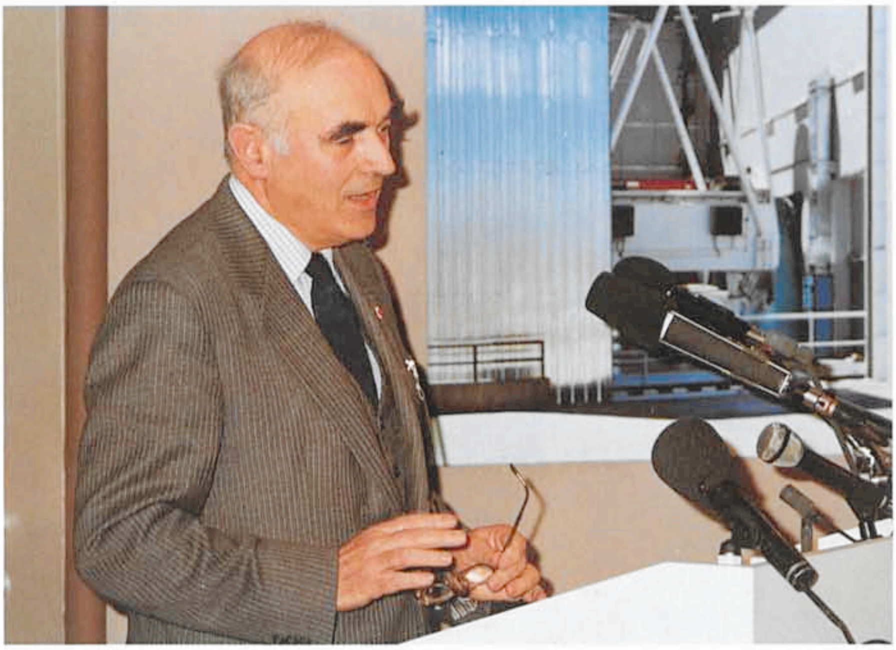
I would first underline the major interests of European associations, of European organizations like ESO. ESO is not the first one, it's not the biggest one, but it is one of the most interesting ones, of the most fruitful ones. Now being an astronomer in Europe, it is a must to cooperate with ESO, as it is a must for particle physicists to cooperate with CERN, as it is a must for a space scientist to cooperate with ESA. We needed some organizations in Europe, we now have this and we are very happy to see how efficient they are.

A second point concerning ESO is that it is a very big centre for studying instrumentation and not only instrumentation for telescopes. All what you have done here in the frame of ESO is indeed very fruitful, very useful for astronomers, but there are also many technological spin-offs, useful in many fields of physics and mechanics. I think that also for Europe this is really of great value.

Another point I wanted to say is that here at ESO there is a place where people meet to discuss their plans, their hopes and their needs for the coming years. We need such places in Europe within the big fields of science, places where people can meet informally, discussing, asking for something – asking from time to time a bit too much – but it's always interesting to have the measure of the maximum. I can assure you and I'm sure that our colleagues here are of the same spirit, that on the side of the governments we are really doing all the best we can to improve the situation of our scientists. Well, it is'nt so bad in our countries, in Europe!

What we did achieve, for example in astronomy, is a model we can follow in other fields in which we have no such cooperation yet. For instance, what do you think about the possibility to have such a cooperation and coordination in oceanography? We have very great ambitions in our countries in Europe. There have already been very important national achievements in oceanography, but I think we could make more if we had something like ESO in order to discuss plans and to see in which directions we should move within this very important field of activity.

I will not be too long, but I would like to make a last remark: Pushing a button, our colleagues have shown that it is very easy to control from here something which is almost at the antipodes. But of course it is easy. Is it not easy to control a satellite which is turning around Venus or going to the very end of our planetary system? The geography now is not at all what it was 20 or 40 years ago. When we are achieving some projects for science we can now think in more global terms – and not only European ones. More and more we will go in this direction, for instance if we think about meteorology or environmental studies. More and more we must have this in mind and more and more we can also realize this.



In conclusion, je voudrais vous souhaiter à tous, à l'ESO, à tous les collaborateurs de l'ESO le meilleur succès, un superbe résultat pour ce télescope qui vient d'être béni et inauguré et aussi une très belle réussite pour la prochaine étape, le Très Grand Télescope. Merci.

Editors note: The speeches by Prof. van der Laan, Dr. Wilson, Prof. Tarenghi, Prof. Lindblad, Mr. Hofstadt and Prof. Ruberti have been reprinted from written texts received. The texts by Ambassador Keusch, Dr. Riesenhuber, Monsignor Cox and Prof. Curien are slightly edited transcriptions of the recorded speeches.

First Announcement

ESO/EIPC Workshop on SN 1987 A and other Supernovae

17–22 September 1990

A joint ESO/EIPC workshop on SN 1987 A and other supernovae will be held from 17 to 22 September, 1990, at the Elba International Physics Centre, Marciana Marina, Isola d'Elba, Italy.

Topics of the workshop:

- SN 1987 A compared to other supernovae
- X-rays, UV, optical, IR and radio observations
- Models and synthetic spectra
- Explosive mechanisms and nucleosynthesis
- Molecule and dust formation
- Pulsars and late-time energy deposition

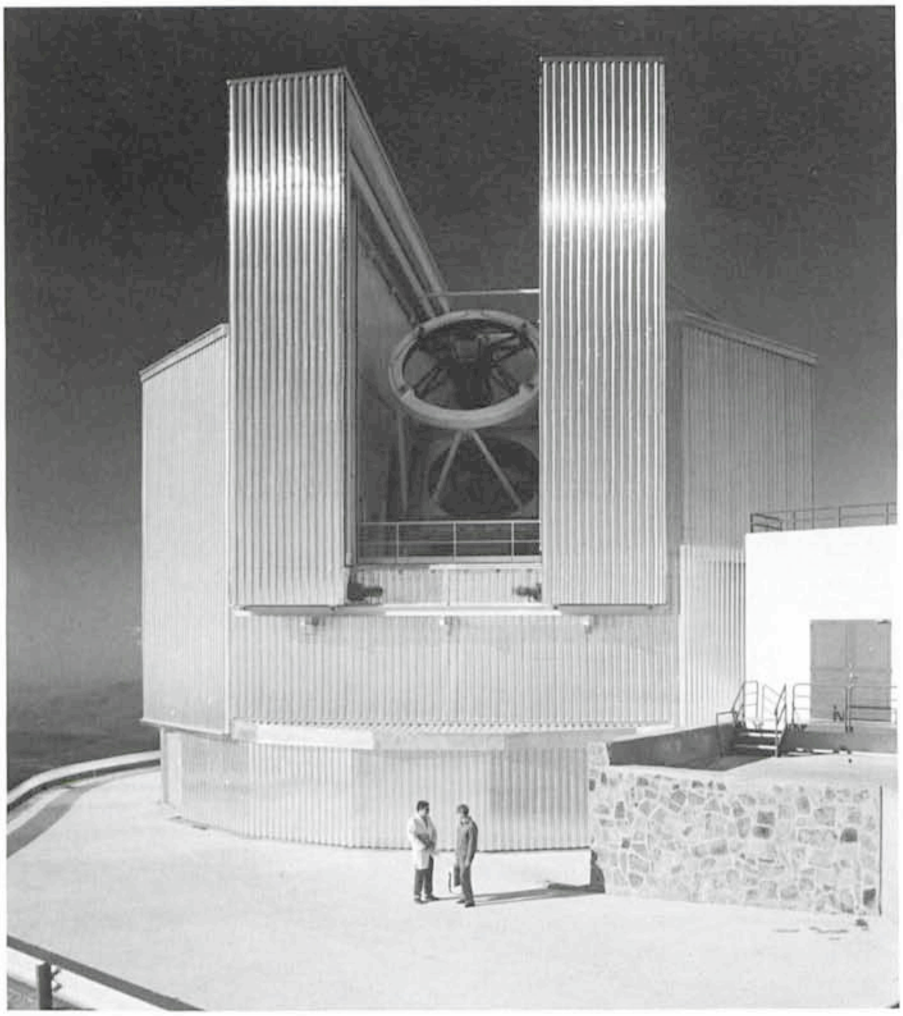
Organizing Committee:

I.J. Danziger (ESO), F. Ferrini (Pisa), W. Hillebrandt (MPI Garching), L. Lucy (ESO).

For further information please contact:

John Danziger, European Southern Observatory, Karl-Schwarzschild-Str. 2, D-8046 Garching, Fed. Rep. Germany

NTT Image Gallery



The ESO New Technology Telescope Building

The ESO New Technology Telescope (NTT) is here seen in its peculiar building at the La Silla Observatory. The telescope incorporates various new technologies; it is the first with an "active optics" system which keeps its 3.58-metre main mirror in perfect shape.

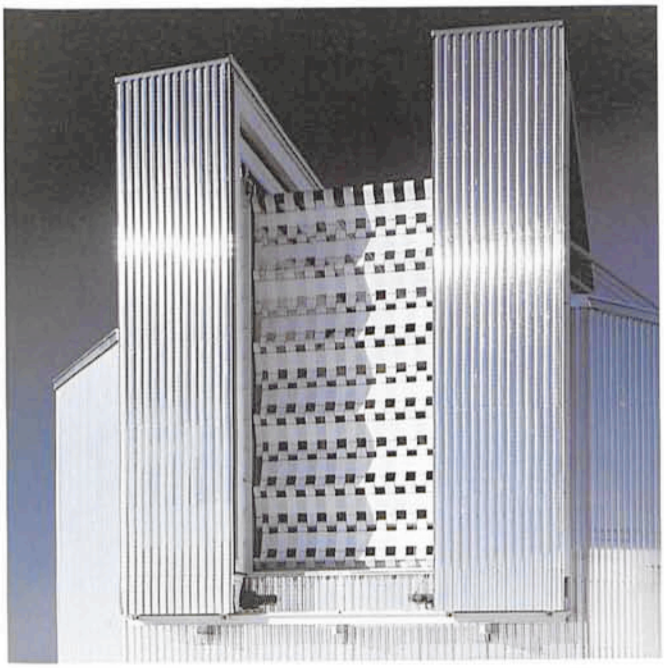
The telescope has one vertical and one horizontal axis (this type of mounting is referred to as "alt-azimuthal"). The building rotates with the telescope during the observations.

The NTT was erected at La Silla during 1988–89. The first regular astronomical observations were made in January 1990 and it was inaugurated on February 6, 1990.

The NTT 3.58-metre Main Mirror

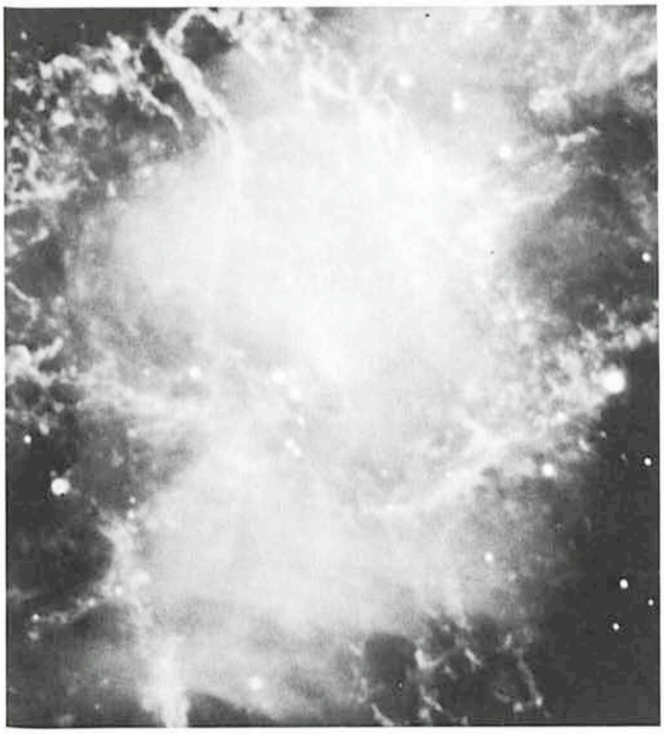
The 3.58-m main mirror of the ESO New Technology Telescope is made of the glass ceramic material "Zerodur". It is comparatively thin (thickness 24 centimetres) and weighs 6 tons.

It is mounted in such a way that it is completely exposed to the surrounding air. This ensures that the mirror always has the same temperature as the air around it and also that the air flow over the mirror surface is as uniform as possible. In this way, the NTT is able to produce the sharpest possible astronomical images.



The NTT Windscreen

During periods of high winds, the ESO New Technology Telescope is protected by a windscreen. It is elevated in front of the telescope to an appropriate height so that it does not impede the observations. In this way wind buffeting on the telescope structure is avoided and the NTT remains stable, even during wind speeds up to 70 km/h.



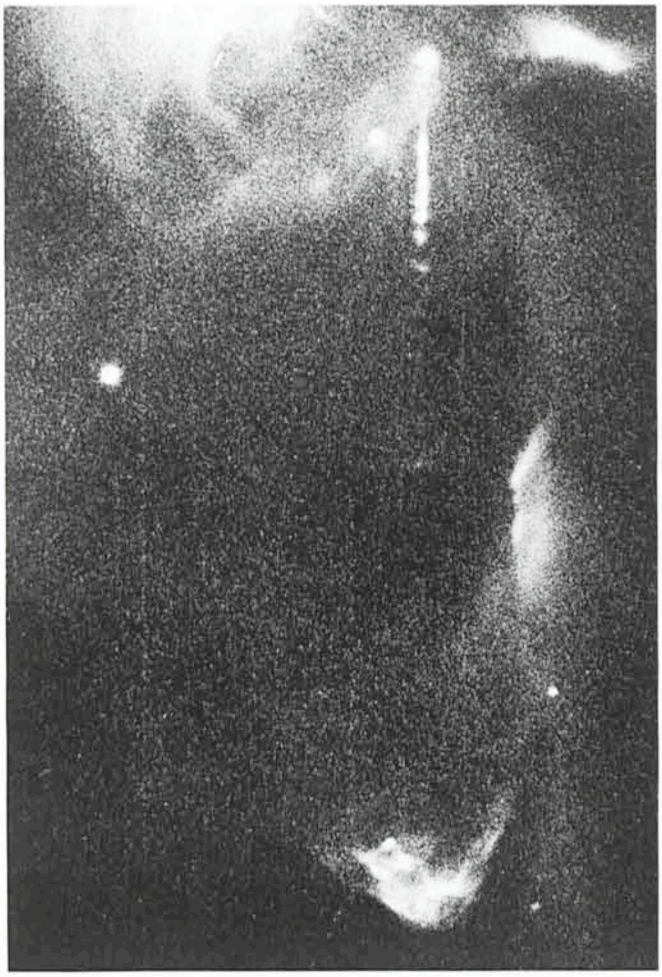
The Central Area of the Crab Nebula

The Crab Nebula, one of the most famous objects in the northern sky, was observed rather low above the La Silla horizon (altitude $\sim 35°$) with the NTT. Despite this adverse condition, the picture shows in great detail the complex structure. The Crab Nebula is the remnant of a supernova which exploded in the year 1054.

This view of the central area was obtained with a CCD camera through a red broad-band filter. It depicts both the filamentary structure mainly emitting in the light of hydrogen atoms, as well as the diffuse background light from electrons being accelerated in the magnetic field in the nebula (the synchrotron process).

The central pulsar is the lower right one of the two brighter stars near the centre. The "Wisp Nebula" lies to the right of the pulsar.

Technical data: Exposure: 3 minutes; Filter: R; Seeing: 0.70 arcsec; Field: $\sim 140 \times 145$ arcsec; Date: December 18, 1989; Observer: Massimo Tarenghi.



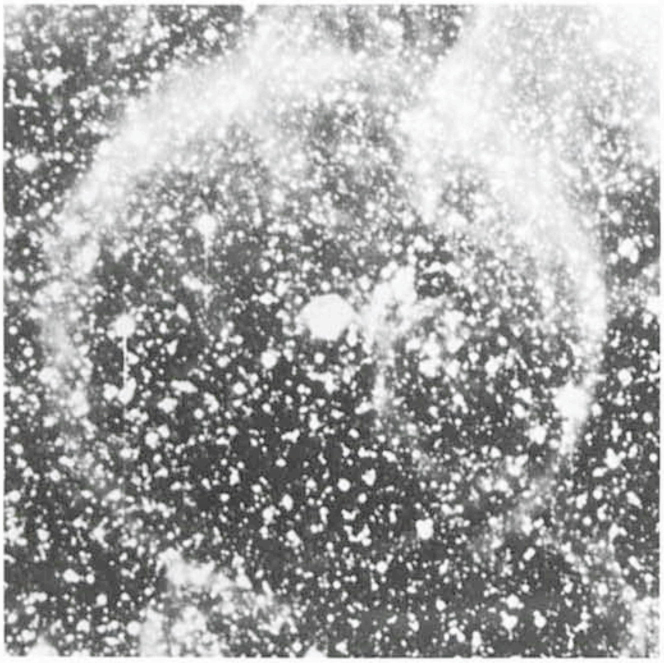
Herbig-Haro Object No. 34

The northern part of the L1641 cloud in Orion contains a large number of small nebulae, known as Herbig-Haro (HH) objects. There are also several jets; one of the most prominent is associated with the HH-34 nebula. It is here shown in a red CCD exposure with the ESO New Technology Telescope.

The jet consists of a large number of knots with typical widths of about 0.6 arcsecond, i.e. they are just resolved on this picture which was obtained with the NTT under very good seeing conditions.

The jet originates at a young star (near the top) and points straight towards HH-34 (bottom) at a distance of 100 arcseconds from the source of the jet (46,000 A.U. or $7 \cdot 10^{12}$ km). The nebula has a typical bow shape and is seen where the jet rams into the surrounding interstellar cloud. It shines in the light of excited atoms and ions. Most of the radiation seen on this photo comes from hydrogen.

Technical data: Exposure 15 min; Filter R; Seeing 0.55 arcsec; Size of field: $\sim 77 \times 110$ arcsec; Date: December 3, 1989; Observer: Bo Reipurth.



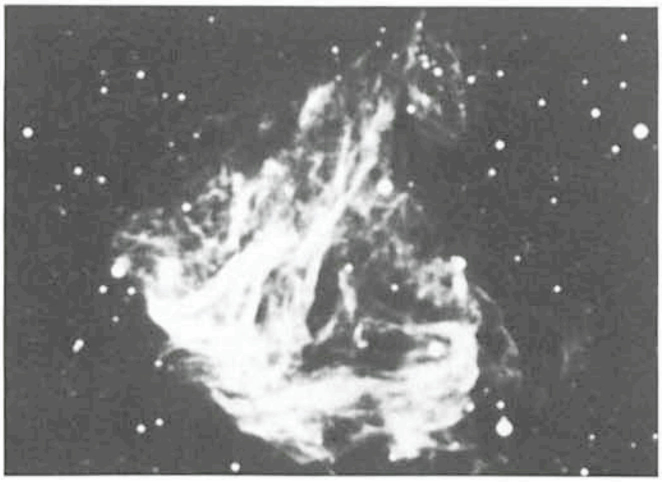
Light Echo Around SN 1987 A

Supernova 1987 A exploded in the Large Magellanic Cloud in February 1987. It was the first naked-eye supernova in nearly four hundred years.

A "light echo" was discovered around this supernova in early 1988. It is light from the supernova, reflected in interstellar dust clouds in the LMC, located in front of the supernova.

This NTT image shows the outer light echo in mid-December 1989. The supernova is the object at the centre, which is shaped as "Napoleon's Hat". The light echo is the bright circular feature extending nearly all the way around the supernova at a radial distance of about 1 arcminute. On this high-resolution CCD image, some structure can be perceived in the light echo. In particular, there are obviously multiple rings in some directions. This corresponds to the spatial distribution of the reflecting dust clouds.

Technical data: Exposure: 10 minutes; Filter: R; Seeing: 0.50 arcsec; Field: 130 × 130 arcsec; Date: December 18, 1989; Observer: Massimo Tarenghi.

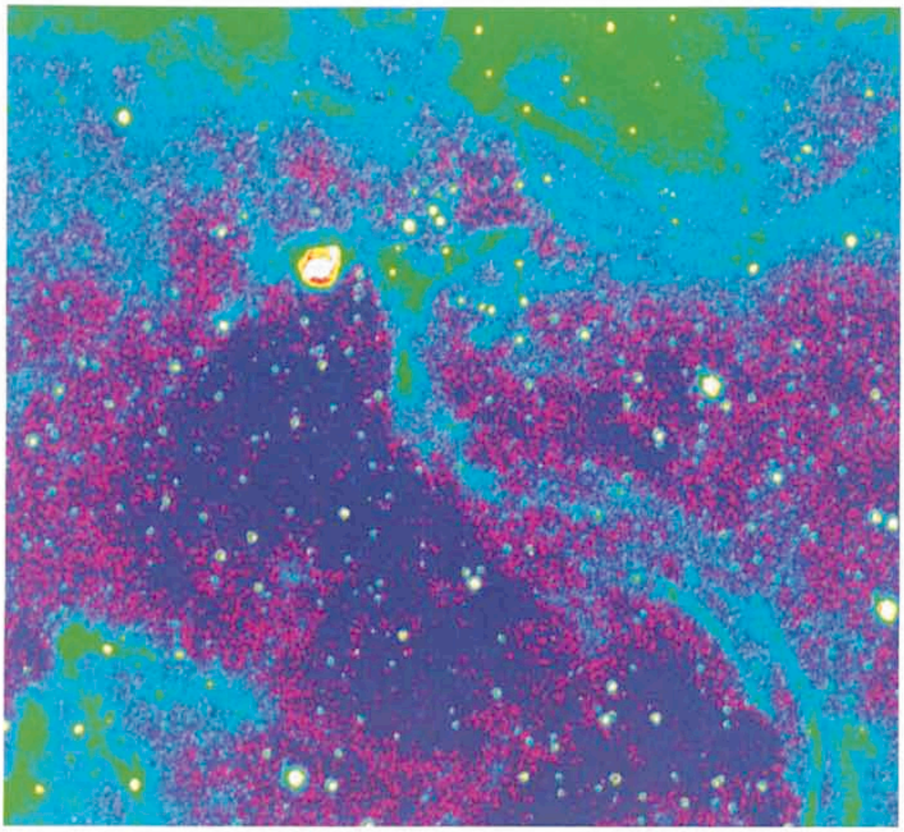


Supernova Remnant N 49 in the LMC

The beautiful filamentary structure of the supernova remnant N 49 in the Large Magellanic Cloud is well brought out on this short CCD exposure with the NTT. It was obtained in red light and most of the emission seen on this image comes from hydrogen atoms.

The nebula was first catalogued by American astronaut-astronomer Henize in 1955. It is located about three degrees due north of the LMC bar. The N 49 nebula is also a source of strong radio emission.

Technical data: Exposure: 3 minutes; Filter: R; Seeing: 0.78 arcsec; Field: 105 × 75 arcsec; Date: January 6, 1990; Observer: Holger Pedersen.



The Surroundings of Supernova 1987 A in the LMC

A CCD exposure of Supernova 1987 A in the Large Magellanic Cloud was made with the NTT in the light of nitrogen ions, under very good seeing conditions. The image is shown in false colours to enhance faint variations of the surface intensity.

It is seen that the supernova is situated at the northern end of a region that is comparatively void of interstellar material. It almost appears as if the progenitor star of the supernova has been moving in this direction, leaving a trail behind. However, the motion of the supernova has not yet been measured, so this is so far only a hypothesis.

A small nebula is seen around the supernova.

Technical data: Exposure: 5 minutes; Filter: [N II] 658 nm; Seeing: 0.45 arcsec; Field: 125 × 115 arcsec; Date: December 18, 1989; Observer: Massimo Tarenghi; Image processing: Joe Wampler; False-colour representation to enhance details.

Dwarf Galaxy NGC 625

The small, irregular galaxy on this NTT CCD image is NGC 625 in the southern constellation of Phoenix. The distance is not well known, but it is probably somewhere between 20 and 30 million light-years.

The exposure was made through a red filter and shows the overall structrure of the galaxy. The brightest stars are well visible as rather sharp points of light, while the emission nebulae are more diffuse.

Note also the dust lanes which hide the light from stars behind them and therefore appear as darker patches among the bright stars and nebulae.

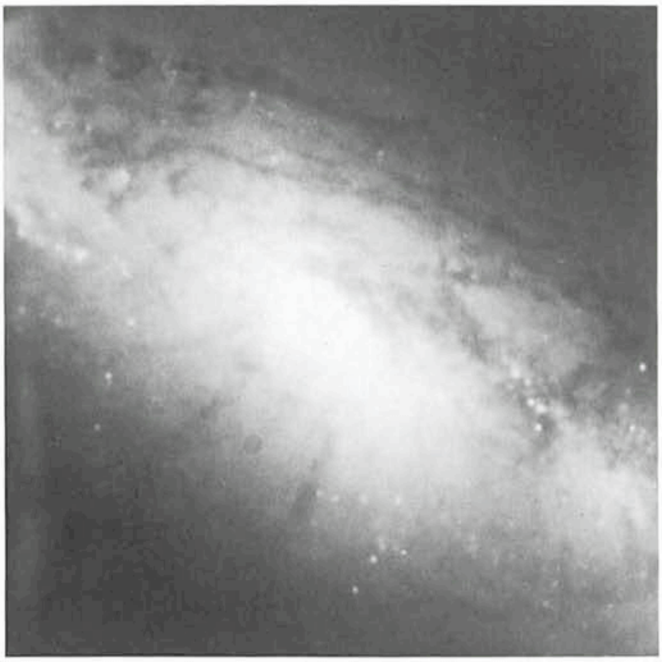
Technical data: Exposure: 90 seconds; Filter: R; Seeing 0.68 arcsec; Field: 140 × 105 arcsec; Date: December 31, 1989; Observer: Jorge Melnick.

The Peculiar Galaxy ESO 060-IG 26

Far down in the southern sky, on the border between the constellations of Volans and Carina, lies this small group of galaxies. It was first discovered at ESO in 1974. The central galaxy is visibly disturbed and now carries the designation "ESO 060-IG 26". The less disturbed galaxy of elliptical shape is "ESO 060-G 27". The distance to the system has not yet been measured, but is probably in excess of 150 million light-years.

This excellent NTT exposure shows in hitherto unknown clarity the peculiar structure of the galaxies in this group. The strange forms are the result of a "recent" galaxy encounter, during which the mutual gravitational attraction pulled out stars and interstellar matter, from ESO 060-IG 26.

Technical data: Exposure: 10 minutes; Filter: R; Seeing: 0.54 arcsec; Field: 115 × 115 arcsec; Date: December 24, 1989; Observer: Massimo Tarenghi.



Violent Motion in NGC 1808

NGC 1808 is a large spiral galaxy in the southern constellation of Columba. This NTT picture of its inner regions give an impression of violent motion; this is confirmed by spectroscopic observations.

There is a strong radio source at the centre of this galaxy and it is classified as being of Seyfert type.

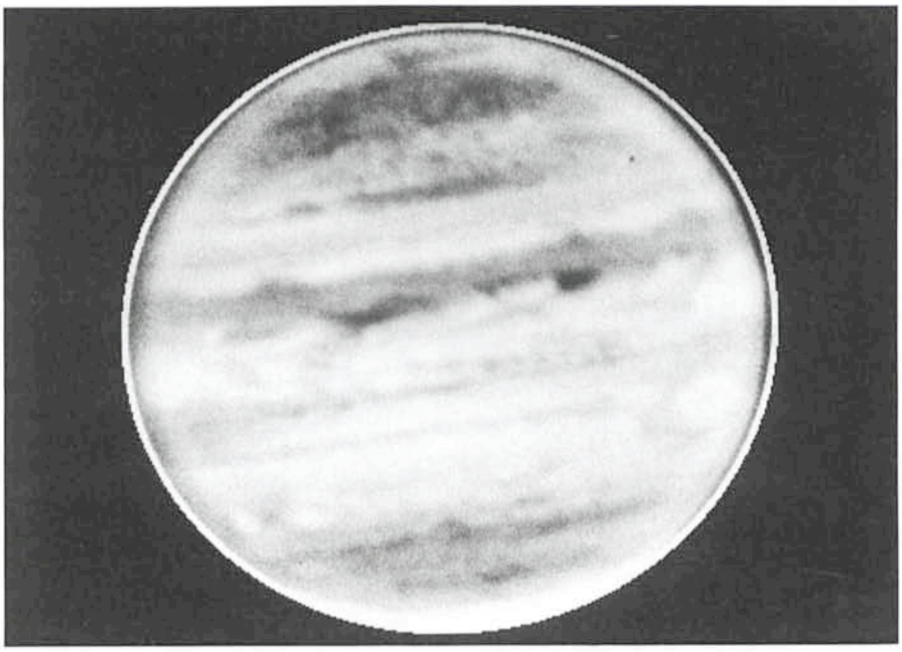
Technical data: Exposure: 6 minutes; Filter: R; Seeing: 0.71 arcsec; Field: 115 × 115 arcsec; Date: December 15, 1989; Observer: Massimo Tarenghi.

Distant cluster of galaxies

One of the main uses of the NTT will be observations of very faint and distant galaxies. It is particularly well suited to such studies, thanks to its great light-gathering efficiency.

On this 15-minute exposure is seen a distant cluster of galaxies in the southern constellation of Hydra. The brightest galaxies have magnitudes around 18; the faintest objects which can be perceived on this photo are close to magnitude 26. Some of these are stars in the Milky Way Galaxy, others are extremely distant galaxies. The good resolution of the NTT facilitates the separation of the two types of objects – the images of galaxies are more diffuse than those of stars.

Technical data: Exposure: 15 minutes; Filter: R; Seeing: 0.75 arcsec; Field: 150 × 98 arcsec; Date: 23 December 1989; Observer: Edmond Giraud.



Infrared Image of Giant Planet Jupiter

This is a very short CCD exposure of the giant planet Jupiter, obtained with the NTT through an infrared filter with a passband near 1000 nm. At the time of the observation, Jupiter was only 35° above the northern horizon at La Silla.

The image has been subjected to moderate image processing: the intensity over the surface has been flattened to bring out small intensity variations over the entire surface.

The image shows many of the bands in the Jovian atmosphere, and also some of the whirls in these bands. The Great Red Spot in the south is not very prominent in this spectral band, but is still faintly visible near the western rim. None of the satellites were in transit at the moment of observation.

This is an excellent image by a ground-based telescope; the smallest features which can be perceived (that is the linear resolution) on Jupiter's disk measure about 2000 kilometres.

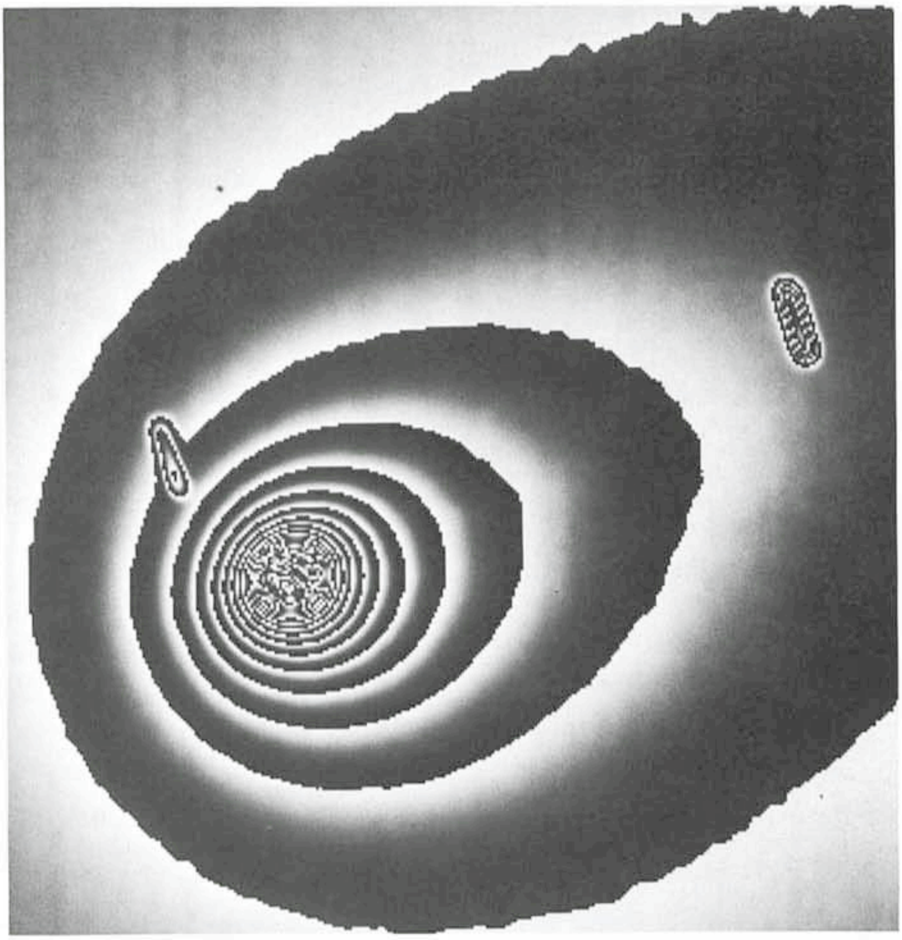
Technical data: Exposure: 0.03 second; Filter: Gunn-z; Diameter of Jupiter's disk: 47 arcsec (equator); Seeing: 0.6 arcsecond; Date: UT January 6.174, 1990; Observer: J. Melnick; Image processing at ESO Headquarters with IHAP/MIDAS.

Comet Austin

This is a short NTT CCD exposure of the newly discovered Comet Austin (1989 c 1) which may become comparatively bright during mid-April 1990 when it approaches the Sun to within 50 million kilometres. On May 25, it will be only 36 million kilometres from the Earth. After mid-April, it will be well visible from the northern hemisphere in the early morning.

Curves of equal brightness (isophotes) are shown. The stars in the field are trailed because the telescope was set to follow the comet's motions. On this date, the comet had not yet developed a real tail and the image shows the dust cloud (coma) around the nucleus which is overexposed on this image. It is situated at the centre of the isophotes. At the time of the exposure, the comet was nearly 300 million kilometres from the Earth and 255 million kilometres from the Sun, still outside the orbit of planet Mars. The magnitude was about 9.

Technical data: Exposure: 5 minutes; Filter: R; field: 75 × 75 arcsec; Seeing: 1.2 arcsec; Date: January 23, 1990; Observers: P. Bouchet, J. Melnick, L. Pasquini and Ch. Gouiffes.



Professor Pierre Charvin, † January 24, 1990

On January 25, 1990 we at ESO were shocked and saddened by the message of Pierre Charvin's death. President of the Observatoire de Paris and astronomy leader in France, Prof. Charvin always showed a deep interest in ESO affairs and contributed through the years to the development of ESO's relations with astronomical institutes in his country.

The past five years he was a member of our Scientific-Technical Committee and for the last two years he energetically served as STC president. In that function he became very involved in the planning of the VLT and its instrumentation.

In an impressive commemorative meeting, in the Salle Cassini of the Observatoire de Paris, attended by his institute's staff and by astronomers from throughout France, I spoke on ESO's behalf, ending as follows:

"De la part de l'ESO, de notre personnel, de notre communauté des utilisateurs, du directorat de l'ESO, du Conseil et du STC, j'exprime notre sentiment de reconnaissance et notre profond respect. Je suis reconnaissant d'avoir la possibilité de faire cela dans cette salle, m'adressant au personnel de l'Observatoire de Paris et à tous ceux qui sont concernés avec 'notre science' en France. Nos pensées et notre sympathie sont destinées à la famille en deuil. Notre mémoire pour Pierre Charvin est marquée par notre admiration pour son enthousiasme et pour son énergie créatrice."

With profound regret to miss him so prematurely, we pay tribute to this prominent colleague and friend.

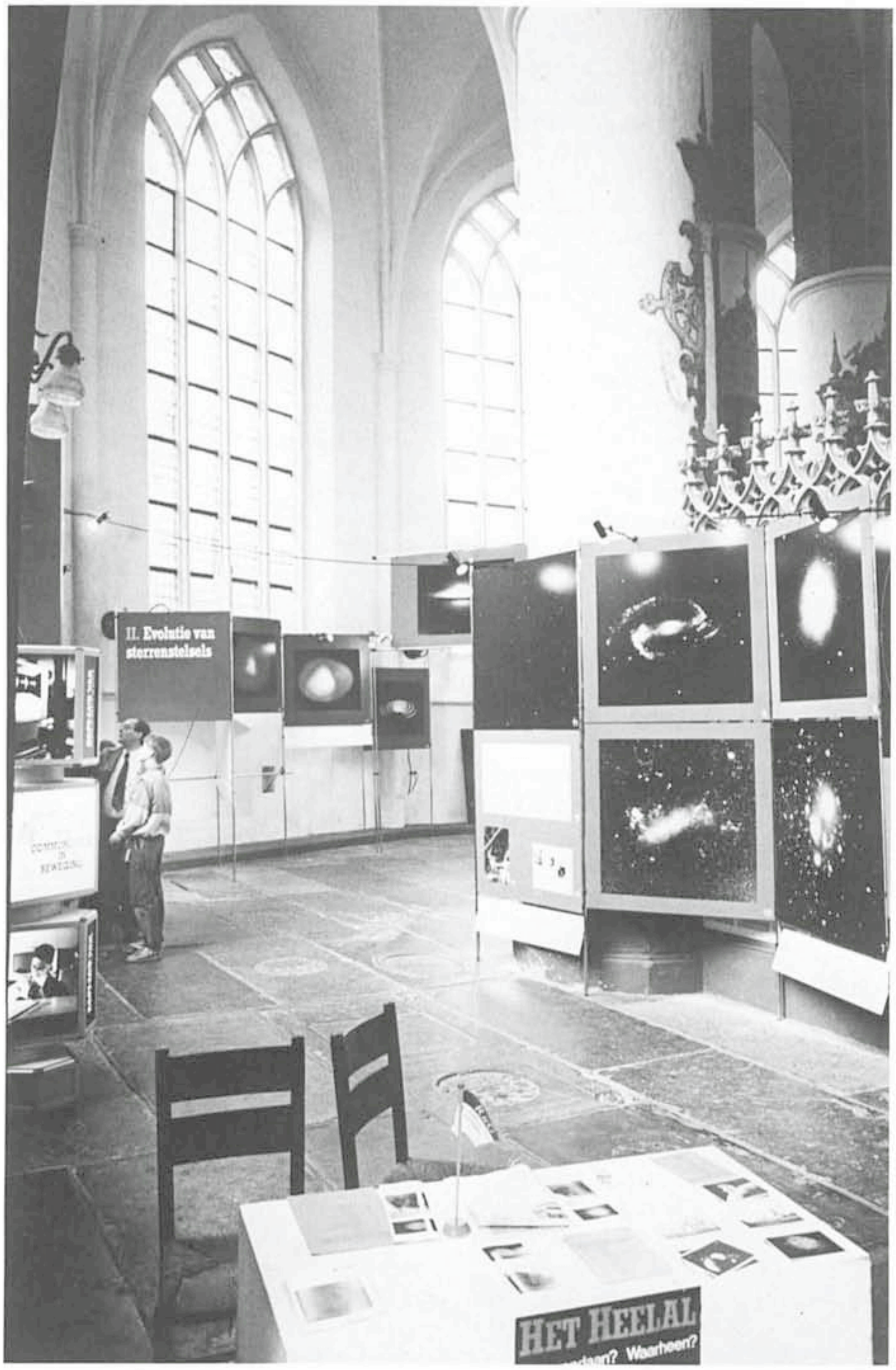
Harry van der Laan
Director General

New ESO Scientific Preprints

(December 1989–February 1990)

680. I. J. Danziger et al.: Molecules, Dust and Ionic Abundances in SN 1987A.
L. B. Lucy et al.: Dust Condensation in the Ejecta of SN 1987A, II.
P. Bouchet et al.: The ESO Infrared Data Set.
To be published in *Supernovae*, Proceedings of the 10th Santa Cruz Summer Workshop in Astronomy and Astrophysics, held at UC Santa Cruz, July 10–21, 1989, ed. by S.E. Woosley (Springer-Verlag, New York).
681. S. di Serego Alighieri, G. Trinchieri and E. Brocato: Hα Imaging of X-ray Luminous Early-type Galaxies: Clues on the Hot, Warm and Cold Phases of the ISM. To be published in *Windows on Galaxies,* Fabbiano et al. (eds.), Proc. of Workshop in Erice, 21–31 May 1989.
682. M. R. Rosa and J. S. Mathis: Wolf-Rayet Nebulae – Chemical Enrichment and Effective Temperatures of the Exciting Stars.
M. R. Rosa: Atomic Data for and from the Analysis of Gaseous Nebulae. To be published in: Proceedings of the First Boulder-Munich Workshop on Hot Stars, Boulder, CO, August 1989, C. D. Garmany (ed.), Publ. A. S. P. Conf. Ser.
683. B. Barbanis: Escape Regions of a Quartic Potential. *Celestial Mechanics.*

684. G. Zhao and P. Magain: The Abundance of Scandium in Extreme Metal-Poor Dwarfs. Submitted to Elba Workshop "Chemical and Dynamical Evolution of Galaxies".
685. M.-P. Véron-Cetty and L. Woltjer: Galaxies Around Luminous Quasars. *Astronomy and Astrophysics.*
686. M. Sarazin: ESO Site Evaluation for the VLT. To be published in the *Astrophysics and Space Science* issue devoted to the Proceedings of the XI European Regional Meeting of the IAU, Teneriffe, 3–9 July 1989.
687. F. Fusi Pecci et al.: The Variation of the Red Giant Luminosity Function "Bump" with Metallicity and the Age of the Globular Clusters. *Astronomy and Astrophysics.*
688. G. Zhao and P. Magain: The Chemical Composition of the Extreme Halo Stars: II. Green Spectra of 20 Dwarfs. *Astronomy and Astrophysics.*
689. M. Heydari-Malayeri: Discovery of a Low Mass B[e] Supergiant in the SMC. *Astronomy and Astrophysics.*
690. P.A. Shaver: Radio Recombination Lines at 25 – A Summary of IAU Colloquium No. 125, Puschino, U.S.S.R. To be published in *Radio Recombination Lines: 25 Years of Investigation.* IAU Colloquium No. 125, eds. M.A. Gordon and R.L. Sorochenko. Kluwer Academic Publishers, Dordrecht, the Netherlands.
691. T. Le Bertre: Observational Study of CS 776. *Astronomy and Astrophysics.*
T. Le Bertre, S. Deguchi and Y. Nakada: Contribution to the Interpretation of Carbon Stars Associated with Oxygen-Rich Circumstellar Envelopes. *Astronomy and Astrophysics* Letters.
T. Le Bertre and L.-Å. Nyman: Observations of 86 GHz SiO Maser Emission in Late-type Stars. *Astronomy and Astrophysics.*
T. Le Bertre and H.-E. Schwarz: Photometric and Polarimetric Observations of two IRAS Galactic Sources. *Astronomy and Astrophysics.*
692. F.R. Ferraro et al.: CCD-Photometry of the Galactic Globular Cluster NGC 2808. *Astronomy and Astrophysics Suppl.*
693. P. Bonifacio, F., Castelli and P. Molaro: Chemical Abundances of Two New Extremely Metal Poor Stars. To be published in Proceedings of Elba Workshop on "Chemical and Dynamical Evolution of Galaxies", 4–14 September 1989.
694. F. Matteucci and E. Brocato: Metallicity Distribution and Abundance Ratios in the Stars of the Galactic Bulge. *Astrophysical Journal* Letters.
695. Bo Reipurth: FU Orionis Eruptions and Early Stellar Evolution. Review presented at IAU Symposium No. 137 "Flare Stars in Star Clusters, Associations and the Solar Vicinity", Byurakan, Armenia, USSR, October 23–27, 1989.
696. B. Reipurth et al.: Spectroscopic Pre-Main Sequence Binaries I. Improved Elements of V 826 Tauri. *Astronomy and Astrophysics.*



"Evolution in the Universe"

An exhibition with this title was held last year on the occasion of the 375th anniversary of the University of Groningen. According to the organizers, more than 10,000 people saw the exhibition, to which also ESO contributed. From Groningen, it has now moved to Enschede and it can later be seen in The Hague over the summer, in connection with the COSPAR Plenary Meeting. Here is a view from the set-up in Groningen (photo Wim Melis).

BBC Makes ESO Film

Late last year, the well-known popularizer of astronomy Dr. Patrick Moore, producer Pieter Morpurgo and a camera crew from BBC-TV paid a visit to La Silla in order to produce a new film about ESO. Made on ESO's behalf, this film is a general introduction to the organization and the work carried out at La Silla and Garching. The film substitutes the previous ESO film which was made in 1985.

At the same time, the BBC team prepared two programmes for the popular Sky at Night TV series, which has run on BBC every month for more than 30 years. Devoted to the NTT, the first of the two programmes was broadcast in

February 1990 and the second programme, about millimetre astronomy, is due to be shown very soon. The pictures show Patrick Moore and his team "in action" interviewing Jorge Melnick and Ray Wilson for the NTT programme.

The new ESO film had premiere on February 6, at the time of the NTT Inauguration. *C. Madsen (ESO)*

Caltech and ESO Join Forces to Produce Sky Atlas

The California Institute of Technology (Caltech) of Pasadena, California, U.S.A., and the European Southern Observatory have concluded an agreement by which ESO will undertake the responsibility of producing high-quality copies of photographic sky survey plates obtained with the Palomar 48-inch Oschin Telescope and to distribute the resulting photographic atlas.

The second Palomar Observatory Sky Survey is a decade-long project to photograph the entire northern sky using sensitive photographic techniques. The new atlas of the heavens, contained on 2,682 glass plates or film transparencies, will serve as the basic astronomical guide to the northern skies for decades to come. It will be known as the *Palomar Observatory – European Southern Observatory Atlas of the Northern Sky.*

"We are delighted that ESO will be copying and distributing the results of the Palomar Sky Survey", says Robert J. Brucato, assistant director of Palomar Observatory. "ESO has considerable experience from their work on the southern sky surveys conducted by ESO and by the United Kingdom Schmidt Telescope in Australia and the results were excellent. We had been planning on doing the copying and distributing at Caltech, but we decided to have the work done at ESO in the interest of making high-quality copies available to the astronomical community at the minimum price possible".

The photographic work at ESO will be carried out by a team of experienced photographers. The laboratory employs highly specialized techniques, many of which were invented at ESO, and which guarantee a minimal loss of information in the copying process. The laboratory staff has more than 15 years of practice with survey and atlas work in the southern sky.

The multi-million dollar Palomar Observatory Sky Survey is funded by grants from the Eastman Kodak Company, the National Geographic Society, the Samuel Oschin Foundation, and the Alfred Sloan Foundation, with additional funding from NASA and the National Science Foundation. Begun in 1986, the survey is scheduled for completion in the mid-1990s. ESO expects to terminate the copying a few years later, having then distributed the entire atlas to astronomical institutes all over the world.

Caltech took its first step in the business of sky surveys in 1948, when Institute astronomers and technicians began the eight-year task of mapping the northern sky for the first Palomar Sky Survey. This proved to be one of the most important developments in 20th century astronomy, because it provided astronomers with an unprecedented wealth of information about the heavens. ESO carried out similar surveys of the southern sky after the erec-

First Announcement

A workshop organized by ESO on

RAPID VARIABILITY OF OB-STARS: NATURE AND DIAGNOSTIC VALUE

will be held from 15 to 17 October 1990 at ESO, Garching, FRG.

The purpose of the workshop is to extensively discuss the various models which have been suggested to explain the rapid variability of early-type stars. In addition to the comparison of observations with models, an attempt will be made to assess the impact, if any, of the variability on the general understanding of OB stars.

Topics include: Observations of O, B, and Be stars – Photometry – Line profiles – Nonradial pulsation – Star spots – Circumstellar structures – Atmospheric diagnostics – Transient phenomena – Mass loss.

The Scientific Organizing Committee consists of H. Ando, D. Baade (chair), C.T. Bolton, H. Henrichs, and L.B. Lucy.

For further information, please write to Dietrich Baade, ESO, Karl-Schwarzschild-Str. 2, D-8046 Garching bei München, or send e-mail to ESOMC1::OBSTARS (SPAN), or OBSTARS@DGAESO51 (EARN/Bitnet), or PSI%026245890024::OBSTARS (X25).

tion of the ESO Schmidt telescope at La Silla, in 1972. Part of this work was done in collaboration with the UK Schmidt telescope in Australia.

In 1980, Caltech astronomers began planning for a new, northern survey because of advances in photographic and telescope technology and the changes in the heavens over the ensuing three decades. The Oschin Telescope was substantially refurbished before the second sky survey was begun. This included a new, $ 380,000 lens that enables the telescope to focus a wide range of wavelengths. In addition, advances in photographic technology have led to the development of photographic plates that are far more sensitive than those available in 1948.

Each glass plate is 14 inches square, and photographs a segment of the sky about 6.5 degrees across, about 13 times the diameter of the full moon. It would take 894 such segments to cover the entire northern hemisphere of the sky, but since each segment is photographed at three wavelengths, the survey will finally comprise 2,682 plates. Because of the trails of overflying airplanes, plate defects, or other observational problems, the Caltech astronomers expect that they will have to expose two plates for every one that is finally accepted for the survey.

Orders for the new Atlas should be sent to the ESO Information Service, Karl-Schwarzschild-Straße 2, D-8046 Garching bei München, Federal Republic of Germany.

The cost of one atlas (894 copies each in B, R and I; in total 2,682 copies) is DM 60,000 on film and DM 460,000 on glass, if prepaid. It is also possible to pay before each shipment; in this case an inflation variation will be applied and it is expected that about one-tenth to one-eighth of the total price will be called up each year. Reservations can be made until July 1, 1990.

(From ESO Press Release 2/90)

Near-Ground Seeing on an Interferometric Platform

L. ZAGO, ESO

1. Introduction

The ideal location for an optical telescope, short of being in orbit, would be being magically suspended in the air, out of all ground-induced turbulence. Most observatories try the next best, a location on a steep peak or ridge, in the generally correct assumption that the abrupt rising of the mountain does not give the air flow the time and space to bring ground-induced turbulence on the telescope.

An interferometric observatory, however, which is made of several, possibly mobile, telescopes, will need a much larger flat space than is usually the case for a single telescope. This is in particular the case for the VLT, which requires a large and rather flat platform of the order of 180 × 150 m to accommodate the four main unit telescopes, the optical laboratories and the tracks for the smaller auxiliary telescopes. One may then fear that telescopes located at some distance from the edge of the platform will have their seeing affected by turbulence created along the stretch of flat surface upwind.

The purpose of this article is to describe a simplified model of the near-ground seeing phenomenon aimed at identifying the main influencing parameters and the order of magnitude of their effects.

2. A Simplified C_T^2 Model

The temperature structure coefficient C_T^2 is the local parameter which most suitably represents the optical quality of an atmospheric layer. The local C_T^2 can in principle be expressed in terms of bulk parameters of the atmosphere, such as temperature, pressure, wind velocity and their derivatives. However, a rigourous formulation will generally be very complex for any non-trivial aerodynamic field and the calculation of C_T^2 will require a finite element or difference scheme.

Therefore we will take here some simplifying assumptions in order to derive a simple analytical formulation, which at the price of some quantitative accuracy, yet allows to identify the physical quantities influencing the seeing phenomenon and obtain useful comparative data for different situations.

We start from the relationship of C_T^2 with dissipation rates:

$$C_T^2 = a^2 \varepsilon_\theta \varepsilon^{-\frac{1}{3}} \qquad (1)$$

List of symbols
ε_θ = dissipation rate of temperature variance.
ε = dissipation rate of turbulent kinetic energy.
α^2 = a constant equal to about 3.
θ = potential temperature.
z = height above ground.
U = wind mean velocity.
σ_u = wind turbulent velocity.
u_* = flow friction velocity.
K_H = eddy diffusivity for heat.
K_m = eddy diffusivity for momentum.
k = von Karman's constant ≃ 0.4.
g = gravity acceleration.
q (z) = local vertical heat flux.
q_s = air-ground heat flux.

Neglecting transport in the longitudinal and transversal direction and under conditions of stationary turbulence, the dissipation rates can be expressed as:

$$\varepsilon_\theta = K_H \left(\frac{d\theta}{dz}\right)^2 ; \qquad \varepsilon = K_m \left(\frac{dU}{dz}\right)^2 - K_H \frac{g}{\theta}\frac{d\theta}{dz} \qquad (2)$$

For K_H we take here the expression valid for a stationary boundary layer (K_m is then assumed equal to $K_H/1.35$):

$$K_H = k^2 z^2 \left|\frac{dU}{dz}\right| \qquad (3)$$

In this way C_T^2 is expressed in terms of the vertical temperature and velocity profiles only. One should note that the velocity gradient represents here a scale of the mechanical turbulence: indeed for a stationary boundary layer, the turbulent velocity σ_u (rms of velocity fluctuations) is directly related to the velocity gradient through the friction velocity u_*.

$$\frac{dU}{dz} = \frac{u_*}{kz} = \frac{\sigma_u}{z} \qquad (4)$$

Note also that temperature and velocity are not properly independent variables, as the temperature gradient is linked through K_H to the velocity turbulence by the heat flux equation:

$$q(z) = K_H \frac{d\theta}{dz} = k^2 z^2 \left|\frac{dU}{dz}\right| \frac{d\theta}{dz} \qquad (5)$$

The local flux q(z) is generally a function of the surface-air heat flux q_s, which depends on thermal ground characteristics, solar irradiation and also on wind turbulence as a more turbulent flow will exchange more heat with the ground. For the purpose of parametric evaluation, one can assume the following proportionality:

$$q(z) \propto q_s \propto \frac{u_*^2}{U} \tag{6}$$

One can now use expressions (1) to (6) to compute and compare the seeing of different situations. As a reference case, we shall take a "good seeing" situation for an optimal location on the mountain, that is on the windward edge of the mountain ridge, with the following conditions:

- Mean wind velocity U = 10 m/s.
- Turbulent velocity σ_u = 0.75 m/s. Note that measured values of wind turbulence at any given mean velocity are quite scattered: at Paranal, for instance, for a mean of 10 m/s, the rms may range from 0.4 to 1.4 m/s. We then use expression (4) to get an estimate of the local velocity gradient and evaluate K_H from (3).
- The vertical heat flux is more difficult to estimate. We will assume here a value of 0.009 K m/s: note, for reference, that on a large plain the night-time surface heat flux can be of the order of 0.03 K m/s, while a value of the order of 0.003 K m/s would be typical for the upper surface layer and therefore could be taken in principle for a mountain peak appearing really "suddenly" into the flow. Nevertheless, some concession should be made to surface effects along the slope and therefore the assumed value of 0.009 K m/s. The local temperature gradient is then evaluated from equation (5).

The resulting C_T^2 profile is found in Figure 1 (solid line). Integrating from 5 to 60 m over a vertical line, for a wavelength of 0.5 μm, a pressure of 770 mb, a temperature of 10°, one arrives at a seeing contribution of 0.13 arcsec, indeed a reasonable value for the near ground contribution.

Expressions (1) to (6) already allow some quick-look conclusions about the dependence of C_T^2 on atmospheric parameters: the most immediate is that either no wind turbulence ($\frac{dU}{dz} = 0$), or isothermal conditions ($\frac{d\theta}{dz} = 0$) would mean a zero C_T^2.

The model shows an almost linear dependence of the near-ground seeing with the turbulent velocity: at the reference mean velocity of 10 m/s, the computed seeing varies from 0.06 arcsec with σ_u = 0.4 m/s to 0.28 arcsec with σ_u = 1.4 m/s. With respect to mean velocity the model shows an increase of seeing with lower mean velocities: 0.28 arcsec for U = 5 m/s and the typical corresponding average σ_u of 0.65 m/s. However, one should note that at lower mean velocities the range of associated turbulent velocities become relatively larger: for instance, again at Paranal, for a mean wind of 5 m/s we record σ_u values from 0.1 to 1.1 m/s, so that, in reality, the model is telling us that at low wind mean velocity one may expect a very large scattering (from very good to very bad) of near ground seeing values.

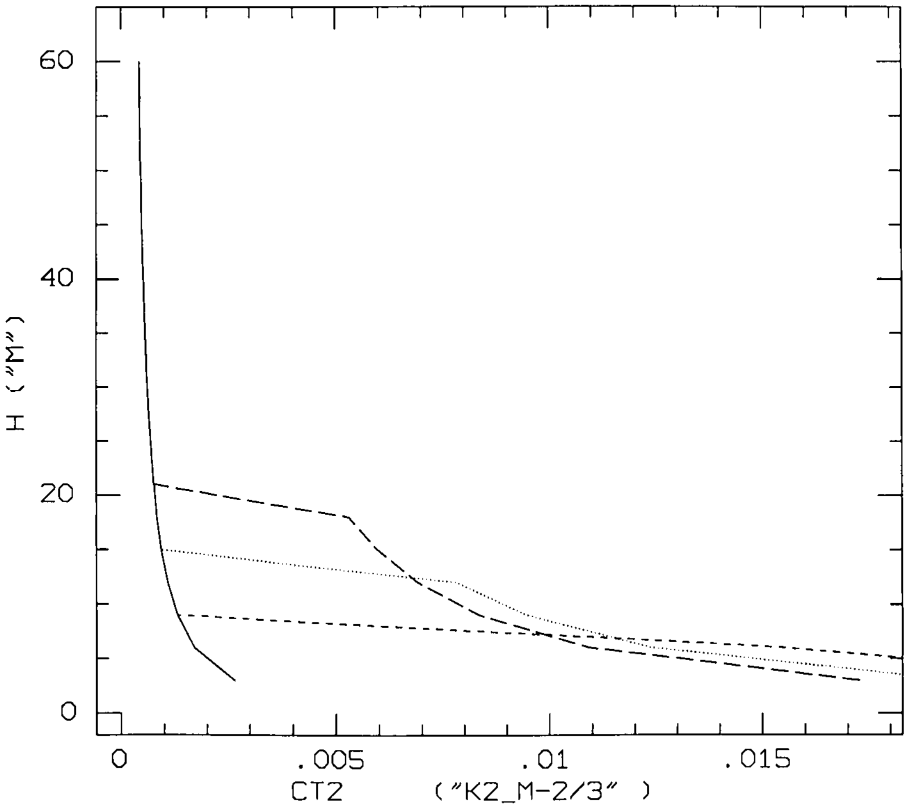


Figure 1: *C_T^2 as a function of height for the reference case at the platform edge (solid line) and for distances of 50, 100 and 150 m respectively (dotted lines) from the edge with z_0 = 0.1 m and $\Delta\theta_s$ = 1°.*

3. Seeing Along an Extended Platform

We will now apply the simplified C_T^2 model to the case where a hypothetic telescope is not located on the mountain peak or ridge but at some distance from it with respect to the prevailing wind direction. In this case the air flow reaching the telescope's field of view will have already "felt" the ground surface upwind:

- Additional turbulence will be caused by the friction along the upwind surface.
- In the likely case of a temperature difference between the air flow and the ground, the convective heat transfer across the flat surface will modify the temperature distribution with respect to the condition in the incoming flow.

When the undisturbed wind flow meets a flat ridge, the surface stress increases immediately. This sudden increase travels upwards so that one can divide the air flow by a boundary line (see Fig. 2): the flow below this line is called the internal boundary layer (IBL) and has been affected by the terrain, the flow above has not. From the consideration that the vertical signal velocity should be proportional to the surface stress, the following equation has been derived which links the height δ of the IBL to the distance ϰ from the edge:

$$1 + \frac{\delta}{z_0}\left(\ln\frac{\delta}{z_0} - 1\right) = kB\frac{x}{z_0} \tag{7}$$

where B is a constant approximately equal to 1.3 and z_0 is the roughness length of the flat surface. Figure 3 shows the evolution of the height δ of the IBL as a function of fetch ϰ, over a length of 200 metres for z_0 = 0.05 m, which corresponds to a smooth ground (for instance the runway area of an airport), z_0 = 0.1 m (countryside with roads

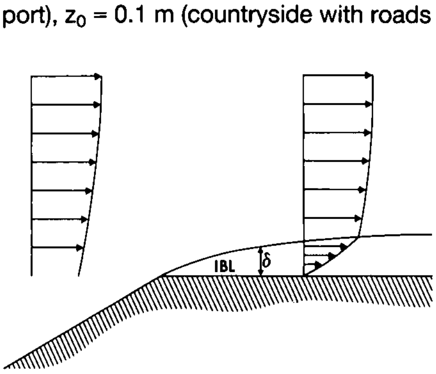


Figure 2: *Growth of the internal boundary layer.*

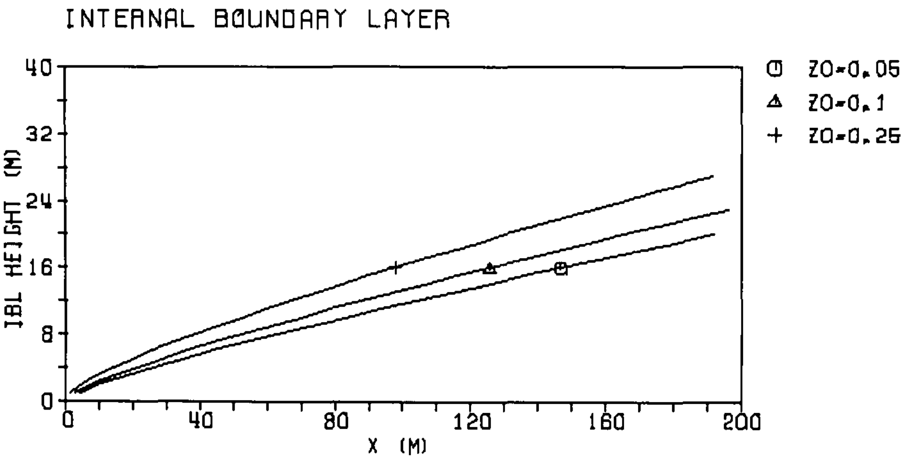


Figure 3: *Height of the internal boundary layer as a function of fetch x for different values of roughness length z_0.*

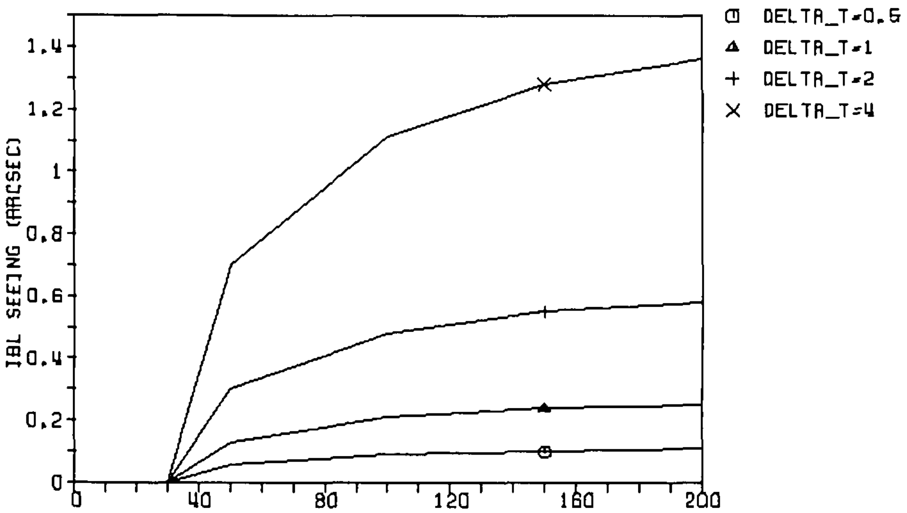


Figure 4: *Seeing in the IBL (integrated from 5 m to the top of the IBL along a vertical line) as a function of fetch x for different values of $\Delta\theta_s$. Note that there are no IBL effects until about 30 m from the edge where the height of the IBL reaches 5 m.*

and a few hedges) and z_0 = 0.25 m (many hedges, a few structures).

Very approximately, velocity profiles below and above δ are logarithmic with different slopes so that a kink appears at δ. From the condition of continuity across the IBL interface one can compute the local friction velocity u^2_{*IBL}, obtaining then $\frac{dU}{dz}$ from (4). The vertical heat flux in the IBL is assumed constant and equal to the average air-surface flux:

$$q(z) = q_s = C_H U \Delta\theta_s = \frac{u^2_{*IBL}}{U^2} U \Delta\theta_s \quad (8)$$

where $\Delta\theta_s$ is the potential temperature difference between the top of the IBL and the ground, while C_H is the bulk heat transfer coefficient, here assumed to be equal to the momentum transfer coefficient for a turbulent boundary layer.

One has now all the inputs for a C_T^2 model in the IBL.

Figure 1 shows the vertical C_T^2 profile computed for x = 50, 100 and 150 m, assuming z_0 = 0.1 m and $\Delta\theta_s$ = 1°: the C_T^2 values in the IBL are in this case about one order of magnitude greater than in the free wind flow. However, because of the short integration path, the high C_T^2 does not necessarily result in an unacceptable seeing contribution, as one can see from Figure 4. Only in case of a strong ground cooling, the IBL seeing becomes relatively large.

4. Conclusions

While it should be reminded that the results computed with this simple model of C_T^2 cannot claim any absolute accuracy, it is nonetheless possible to draw some conclusions from the comparison of different situations.

The height and turbulence of the IBL are dependent on the average roughness of the surface, which a good design should therefore try to minimize, by avoiding raised structures and any kind of obstacles likely to contribute to the turbulence generated locally. However, the stronger effect on the IBL seeing will likely be caused by temperature differences between the ground and the incoming flow: this difference will have to be minimized by selecting surface materials which are lightweight and of low conductivity: for instance porous gravel should be used rather than solid rock. In this way the heat flux through the ground will be reduced and the thermal time constant of the surface will be correspondingly decreased.

In a next article, we will discuss the possible seeing effects in the wake of other structures, which is another important aspect of the design of a multi-telescope observatory.

Visiting Astronomers

(April 1–October 1, 1990)

Observing time has now been allocated for Period 45 (April 1–October 1, 1990). The demand for telescope time was again much greater than the time actually available.

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

3.6-m Telescope

April: Butcher/Slingerland/Pottasch E./Baade/Christensen-D./Frandsen, Boulanger/Falgarone/Gérin/Harmon, Ögelman/Gouiffes/Melnick/Augusteijn/Hasinger/Pietsch, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Chincarini/Buzzoni/Molinari, di Serego Alighieri/Fosbury/Quinn/Schlötelburg/Tadhunter, Reimers/Koester, Tammann/Leibundgut/Stein.

May: Sackett/Jarvis, Magazzù/Strazzulla, Moorwood/Oliva, Hensberge et al. (5-005-45K), Baade/Crane, Reipurth/Dubath/Mayor, Ehrenfreund/Leger/Foing, Möllenhoff/Madejsky, Bertola et al. (1-008-43K), Shaver, Melnick/Gopal-Krishna/Steppe/Giraud, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali.

June: Leinert/Haas, Perrier/Mariotti/Mayor/Duquennoy, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turratto et al. (4-004-45K), Epchtein/Le Bertre/Blommaert/van Langevelde/Nguyen-Quang-R./Winnberg/Lindquist/Habing, Ferlet/Vidal-Madjar/Dennefeld, Rosa/Mathis, Pottasch S.R./Manchado/Garcia Lario/Sahu K.C.

July: Käufl/Stanghellini/Renzini, Lagrange-Henri/Maillard/Vidal-Madjar/Gry/de Muizon/Ferlet/Beust, Glass/Moorwood/Moneti, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Sicardy/Brahic/Barucci/Ferrari/Fulchignoni/Roques, Habing et al. (5-004-45K), Dettmar/Shaw/Klein, Cappellaro/Held/Capaccioli, Held/Cappellaro/Capaccioli, Bertola/de

Zeeuw/Zeilinger, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Morganti/Tadhunter/di Serego Alighieri/Fosbury/Danziger, Nota/Greenfield/Clampin/Paresce.

August: Neri/Grewing/Bässgen M., Bender et al. (1-004-43K), Webb/Carswell/Shaver, Wampler et al. (2-010-45K), Dubath/Melnick/Mayor, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali.

September: Molaro/Castelli/Bonifacio, Borra/Sanvico/Cristiani/Levesque/Shaver, Mazure et al. (1-014-43K), Rhee et al. (1-005-43K), de Lapparent et al. (1-003-43K), Marano/Held/Cappi, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Ögelman/Gouiffes/Melnick/Augusteijn/Hasinger/Pietsch.

3.5-m NTT

May: Jarvis, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Pollacco/Houziaux/Manfroid/Hill, Buonanno/Fusi Pecci/Richer/Fahlmann/Ferraro, Surdej et al. (2-003-43K), Ortolani/Renzini/Rosino.

July: Richtler/Wagner/Held/Capaccioli, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Piotto/Djorgovski, Zinnecker/Moneti/Rosa, Walton/Barlow/Walsh/Clegg, Aurière/Koch Miramond/Ilovaisky/Chevalier/Lauzeral.

August: Meylan/Djorgovski/Shaver/Weir, Bender et al. (1-004-43K), Surdej et al. (2-003-43K).

September: Miley et al. (2-001-43K), Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Bergeron et al. (1-012-43K).

2.2-m Telescope

April: Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), v.d. Hucht/Thé/Williams, Test-Moorwood, Moneti/Zinnecker/Reipurth, Dougados/Rouan/Léna, (Bernard/Loup/Giard), Moeller/Kjaergaard, Surdej et al. (2-003-43K), Reinsch/Pakull/Festou/Beuermann/Burwitz, Sackett/Jarvis, Hutsemekers/van Drom, Reinsch/Pakull/Festou/Beuermann/Burwitz, Hutsemekers/van Drom.

May: MPI time.

June: Test-Moorwood, Epchtein/Le Bertre/Blommaert/v. Langevelde/Nguyen-Quang-R./Winnberg/Lindquist/Habing, Hopfensitz/Grewing, (Ehrenfreund/Käufl/), (Foing/d'Hendecourt), Reinsch/Pakull/Festou/Beuermann/Burwitz, Richtler/Kaluzny, Alcaíno/Liller/Alvarado/Wenderoth, Spaenhauer/Labhardt, Glass/Moorwood/Moneti.

July: Glass/Moorwood/Moneti, Wink/Greve, v.d. Veen/Blommaert/Habing, Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Dettmar/Shaw/Klein, Tosi/Focardi/Greggio/Marconi, Bertola/de Zeeuw/Zeilinger, Longo/Capaccioli/Busarello/Di Martino F., Morganti/Tadhunter/di Serego Alighieri/Fosbury/Danziger.

August: Test-Moorwood, (v.d. Kruit/de Jong R.S.), Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Turatto et al. (4-004-45K), Gustafsson/Eriksson/Olofsson/Lambert/Paresce, Surdej et al. (2-003-

Announcement

12th European Regional Astronomy Meeting

of the International Astronomical Union (IAU)

EUROPEAN ASTRONOMERS LOOK TO THE FUTURE

8–11 October 1990, Davos, Switzerland

organized jointly with the Astronomy and Astrophysics Division of the European Physical Society (EPS)

with support from the European Space Agency (ESA) and the European Southern Observatory (ESO)

Meeting Objectives

The 12th European Regional Astronomy Meeting (ERAM) of the International Astronomical Union (IAU) is a general astronomy meeting covering all fields of astronomy: solar system, stellar, galactic and extragalactic astronomy as well as cosmology. The theme *European Astronomers look to the Future* reflects the positive outlook for ground-based and space astronomy throughout Europe and the new opportunities for Europe-wide cooperation.

Programme Concept

The meeting will be divided into plenary and poster sessions. Forward-looking revies of active scientific areas in astronomy, a few brief reports on particularly exciting unpublished discoveries as well as a brief review of instrument projects and long-range plans in the form of a panel discussion will be scheduled for plenary sessions. Poster sessions will be devoted to contributed papers grouped according to subjects and in most cases accompanied by discussion sessions. In addition, prospective and very recent PhDs will be given ample opportunity to present their work in a separate oral session.

Venue and Timing

The meeting will be held in the Kongreßzentrum, Davos, Switzerland from 8 to 11 October 1990. The meeting will start in the early afternoon of Monday, 8 October, and will end around noon on Thursday, 11 October, to facilitate travel on those days.

Davos, located in the canton of Grisons, can easily be reached by train or car from many countries in Europe and is a three-hour train journey from Zurich airport.

Accommodation

Favourable hotel rates, and very cheap pension accommodation will be available for participants.

Meeting Language

All sessions will be conducted in English.

Special Considerations

It is expected that at least partial support may be granted to deserving young astronomers. Ways to facilitate the participation of astronomers from countries with monetary exchange difficulties are being studied.

Scientific Organizing Committee

J. Bergeron, IAU representative, Paris
A. A. Boyarchuk, Moscow
C. Chiuderi, Arcetri
K. Fredga, Solna
B. Kovachev, Sofia
M. C. E. Huber, EPS representative, Noordwijk
R. Lüst, ESA, Paris
H. van der Laan, ESO, Garching
P. Léna, Meudon
F. Sánchez, Tenerife
J. P. Swings, Liège
G. F. Smith, Manchester
L. Woltjer, St.-Michel-l'Observatoire, Chairman

Swiss Organizing Committee

P. Bochsler, Bern
T. Courvoisier, Genève
C. Fröhlich, Davos
B. Hauck, Lausanne
U. W. Steinlin, Basel, Chairman
J. O. Stenflo, Zürich

Contact Address

To receive the second announcement, which will contain the outline of the programme, an invitation to submit contributed papers, and forms for hotel reservations, funding applications, and registration instructions, please contact:

Professor U.W. Steinlin
Astronomisches Institut
der Universität Basel
Venusstraße 7
CH-4102 Binningen
Switzerland

Calendar

15 April	Second Announcement
15 July	Deadline for return of registration form, hotel reservations, support applications
31 August	Deadline for abstracts of contributed papers
21 Sept.	Final programme to participants
8 October	Abstract booklet

43K), Barbieri et al. (2-007-43K), Bender et al. (1-004-43K).

September: MPI time.

1.5-m Spectrographic Telescope

April: Calvani/Marziani, Courvoisier/Bouchet/Blecha, Acker/Jasniewicz/Duquennoy, Pollacco/Walsh/Tadhunter/Hill, Sivan/Perrin.

May: Renzini/Greggio/Bragaglia, Gerbaldi et al. (5-004-43K), Hutsemekers/van Drom, Bica/Prugniel/Alloin, Paturel et al. (1-017-45K).

June: Paturel et al. (1-017-45K), Bässgen M./Grewing/Diesch, Hron, Greve/McKeith, Courvoisier/Bouchet/Blecha, Polcaro/Giovannelli/Manchanda/Norci/Pollock/Rossi/Viotti, Acker/Stenholm/Lundström, Pottasch S.R./Manchado/Garcia Lario/Sahu K.C.

July: Augusteijn, Gehren/Axer/Fuhrmann/Steenbock/Reile, Longo/Capaccioli/Busarello/Di Martino F., Habing et al. (5-007-45K), Andreae/Drechsel, Walsh/Pottasch S.R./Walton.

August: Ramella/Focardi/Geller, Schmitt/Pasquini, Barbieri et al. (2-007-43K).

September: Gerbaldi et al. (5-004-43K), Rafanelli/Schulz H./Marziani, Falomo/Maraschi/Tanzi/Treves, Bettoni/Bertola/Buson, Claudi/Bianchini/Friedjung/Sabbadin.

1.4-m CAT

April: North, Pottasch S.R./Sahu K.C., Gratton/Sneden, Gratton/Gustafsson/Eriksson, Mauron, Pasquini.

May: Pasquini, Westerlund/Krelowski, Pasquini/Spite M./Restaino, Hutsemekers/van Drom, Gredel/v. Dishoeck/Black, Gredel/v. Dishoeck/Black, Crane/Palazzi/Mandolesi, da Silva/de la Reza/Dore.

June: Wilson/Henkel/Stahl, Gosset/Vreux, Greve/Keenan/Dufton, Boffin/Arnould/Forestini/Isern/Canal/Rebolo/Abia, Holweger/Lemke.

July: Lagrange-Henri/Ferlet/Vidal-Madjar/Beust, Vladilo/Molaro/Centurion/Monai, Cuypers/Waelkens, Benvenuti/Porceddu, François.

August: Andersen/Gustaffson/Saar/Zwaan, Gustafsson/Eriksson/Olofsson/Lambert/Paresce, Van Kerkwijk/Waters/Verbunt/van Paradijs/Coté/Pols/v.d. Heuvel.

September: Crane/Blades/Penprase, Kürster/Schmitt/Cutispoto/Fleming/Dennerl, Kürster/Schmitt/Cutispoto/Fleming/Dennerl, Lagrange-Henri/Ferlet/Vidal-Madjar/Beust, Foing/Jankov/Char/Martic/Doyle/Neff.

1-m Photometric Telescope

April: de Jong/Hu/Slijkhuis, Persi/Origlia/Ferrari-Toniolo, v.d. Hucht/Thé/Williams, Baudzus/Schmidt-Kaler/Hanuschik/Demmer, Courvoisier/Bouchet/Blecha, Sterken/Longo/Busarello, Reinsch/Pakull/Festou/Beuermann/Burwitz.

May: Reinsch/Pakull/Festou/Beuermann/Burwitz, Pottasch S.R./Manchado/Garcia Lario/Sahu K.C., Courvoisier/Bouchet/Blecha, Prugniel/Bica/Alloin, Augusteijn/Nather/Winget.

June: Nyman/Le Bertre/Hall/Norris, Le Bertre et al. (5-006-45K), Courvoisier/Bouchet/Blecha, Giard/Bernard/Dennefeld/Perault/Sales, Munari/Whitelock/Massone, Terzan.

July: Le Bertre et al. (5-006-45K), Sicardy/Brahic/Barucci/Ferrari/Fulchignoni/Roques, Courvoisier/Bouchet/Blecha, Liller/Alcaino/Alvarado/Wenderoth, Di Martino M./Pironello/Mantegazza, Habing et al. (5-007-45K).

August: Habing et al. (5-007-45K), Nieto/Davoust/Poulain/Bender/Capaccioli/Prugniel, Weiss/Schneider/Kuschnig/Rogl, Schmitt/Pasquini.

September: van Kerkwijk/Waters/Verbunt/van Paradijs/Coté/Pols/van den Heuvel, Schneider/Weiss/Kuschnig/Rogl, Schmitt/Pasquini, Di Martino M./Zappalà/Cellino/Farinella/Davis, Foing/Jankov/Char/Martic/Doyle/Neff.

50-cm Photometric Telescope

April: Antonello/Mantegazza/Poretti/Riboni, Kohoutek.

May: Kohoutek, Franchini/Alcalà/Chavarria/Terranegra/Covino/Ferluga/Stalio/Pasquini.

June: Drechsel/Lorenz/Mayer.

July: Sinachopoulos.

August: Debehogne/Di Martino M./Zappalà/Lagerkvist/Hahn/Magnusson/De Campos/Cuypers/Cutispoto.

September: Kürster/Schmitt/Cutispoto/Fleming/Dennerl, Foing/Jankov/Char/Martic/Doyle/Neff.

GPO 40-cm Astrograph

June: Aniol/Duerbeck/Tsvetkov/Tsvetkova.

July: Aniol/Duerbeck/Tsvetkov/Tsvetkova.

September: Debehogne/Machado/Mourao/Caldeira/Vieira/Netto/Zappalà/De Sanctis/Lagerkvist/Protitch-B./Javanshir/Woszczyk.

1.5-m Danish Telescope

April: Lindgren H./Ardeberg/Lundström, Ardeberg/Lundström/Lindgren H., Brocato/Caputo/Castellani, Chevalier/Ilovaisky/Pedersen, Miller/Ballard, Mazure et al. (1-014-43K), Rhee et al. (1-005-43K), Pollacco/Walsh/Tadhunter/Hill.

May: Pollacco/Walsh/Tadhunter/Hill, Andersen/Nordström/Mayor/Olsen, Nordström/Andersen, Danish time.

June: Lindgren H./Ardeberg/Lundström, Ardeberg/Lundström/Lindgren H., Cacciari/Ferraro/Fusi Pecci/Stanghellini/Oculi/Tessicini, Ortolani/Barbuy/Bica, Cacciari/Ferraro/Fusi Pecci/Stanghellini/Oculi/Tessicini, Erkens/Wagner.

July: Danish time.

August: Mayor et al. (5-001-43K), Surdej et al. (2-003-43K), Danziger/Bouchet/Gouiffes/Lucy/Wampler/Fransson/Mazzali, Barbieri et al. (2-007-43K), Azzopardi/Lequeux/Rebeirot, Bender et al. (1-004-43K), Mayor et al. (5-001-43K).

September: Mayor et al. (5-001-43K), Lindgren H./Ardeberg/Lundström, Danish time.

50-cm Danish Telescope

April: Danish time, Ardeberg/Lundström/Lindgren H.

May: Danish time, Ardeberg/Lundström/Lindgren H., Lampens/Dommanget.

June: Lampens/Dommanget, Group for Long Term Photometry of Variables.

July: Group for Long Term Photometry of Variables.

August: Group for Long Term Photometry of Variables.

September: Group for Long Term Photometry of Variables.

90-cm Dutch Telescope

April: de Vries C.P./v. Dishoeck/Blades/Penprase, Martin W./Kohoutek.

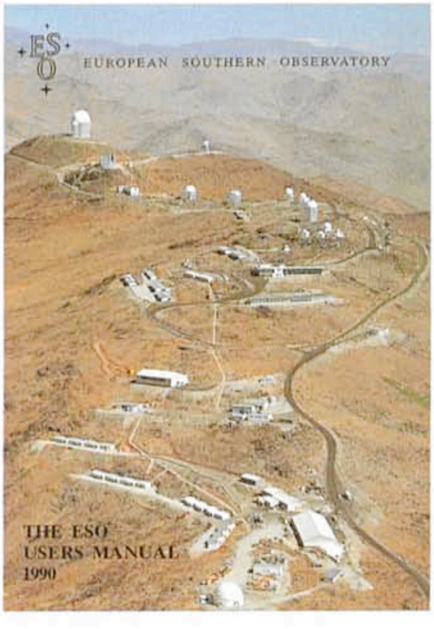
May: Martin W./Kohoutek, Dutch time.

June: Dutch time, van Genderen/v.d. Hucht, van Genderen.

July: van Genderen/v.d. Hucht, van Genderen, Dutch time.

August: Dutch time, van Genderen/v.d. Hucht, van Genderen, de Vries C.P./v. Dishoeck/Blades/Penprase.

September: de Vries C.P./v. Dishoeck/Blades/Penprase, Dutch time.



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D-8046 Garching bei München
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ESO'S EARLY HISTORY, 1953–1975

VI. Further Developments in Chile; 25 March 1969: The First Phase Dedicated; The Introduction of National Telescopes*

A. BLAAUW, Kapteyn Laboratory, Groningen, the Netherlands

"La construcción del observatorio de La Silla --- es un ejemplo notable de lo que se puede lograr por medio de eficiente y, sin duda trascendente, cooperación internacional."
From the speech by Olof Palme on behalf of the ESO member states at the dedication of the Observatory.

The Inauguration

On March 25, 1969, an audience of more than 300 people: members of the ESO Council, Government officials, representatives of AURA, CARSO, IAU and CERN, other guests and staff members of ESO were assembled in the large dome on La Silla which years later would house the Schmidt telescope. They celebrated the completion of the first phase of the construction programme. Three years and one day earlier, the road to the summit had been dedicated and an extensive building programme then lay ahead. Now, the Observatory entered its full operational phase with the middle-size telescopes.

Many speakers marked the occasion: after an introduction by ESO's Director, O. Heckmann, they were, in this order: J. Sahade as Vice President of the International Astronomical Union; Olof Palme, Minister of Education of Sweden; J.H. Bannier, President of the ESO Council; Gabriel Valdes S., Minister of Foreign Affairs of Chile; and Eduardo Frei Montalva, the President of the Republic of Chile; after which the Archbishop of La Serena, Msgr. Juan Francisco Fresno pronounced the benediction. The inauguration proper was pronounced by President Frei, who for this occasion had landed by helicopter on La Silla. At the lunch following the ceremonies, the audience was addressed by the French Minister of Education, Jacques Trorial.

The texts of the addresses, with translations into or from Spanish, have been published in *ESO Bulletin* No. 6 of July 1969. Olof Palme spoke, in Spanish, on behalf of the six ESO Member States. Let me quote some parts of his speech in the English translation:

"The erection of the La Silla Observatory --- is not only of vast importance for the future of astronomical research, but also a striking example of what may be achieved through efficient, and truly far-reaching, international cooperation. --- Scientific progress and interna-

INAUGURATION CEREMONIES ON LA SILLA

On March 25, 1969 inauguration ceremonies took place on La Silla, celebrating the completion of the first construction phase of the Observatory.
The top photograph *shows the President of the Republic of Chile, Eduardo Frei Montalava, pronouncing the inauguration. It took place in the dome which, several years later, would house the Schmidt telescope, before an audience consisting of the ESO Council and many guests among whom Chilean government authorities, representatives of other scientific institutes, and ESO staff.*
The bottom photograph, *taken during one of the preceding speeches, shows in the front row from left to right: Otto Heckmann, Director General of ESO; Gabriel Valdés S., Minister of Foreign Affairs of Chile; Olof Palme, Minister of Education of Sweden; President Frei; and Hendrik Bannier, President of the ESO Council.*
From a series of photographs in the ESO Historical Photographs Archives.

* Previous articles in this series appeared in the numbers 54 to 58 of the *Messenger*.

tional cooperation are important instruments in the realization of the objectives of any modern society."

On the occasion of the inauguration several other events, among which Council's second meeting in Chile, took place to which I shall return later in this article. Let us first look back upon the developments that had led to the completion of the first phase. In the course of the three years since the dedication of the road, buildings for the telescopes, the Hostel, dormitories, workshop, storage space, etc. had been erected and in Santiago the Headquarters building had been completed. We shall not follow these developments here in detail, only main lines will be sketched. The photographs accompanying this article show the changing face of La Silla over these years.

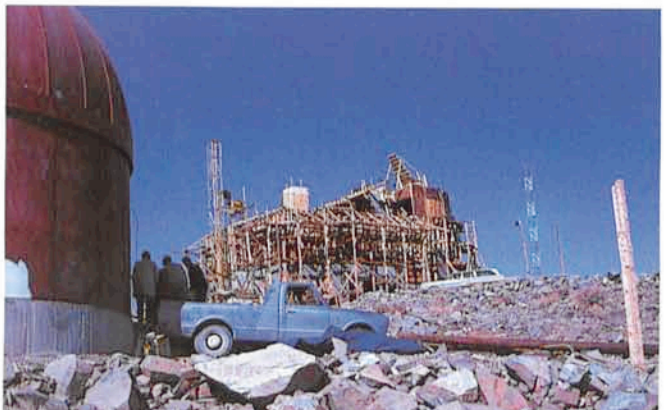
Developments on La Silla, 1967–1969

An interesting report on the situation early 1967 results from a visit to La Silla of the Dutch Ambassador in Chile, D.G.E. Middelburg on 17 February 1967 [1]. He was one of those in the European Diplomatic Corps in Santiago who followed ESO's activities with great interest and active support, and he developed a special relation to ESO through his son Frank [2]. From the Ambassador's report to the Dutch Ministry of Foreign Affairs I quote a few lines in translation from Dutch: "*--- On the mountain I met considerable activity. Provisional lodgings, dining and office rooms are in use since some time. A Dutch telescope is housed in a provisional steel dome. Concrete foundations are now being laid for three large domes and for a hostel. --- As an illustration of the considerable problems that have to be solved, let me mention that all personnel, all building materials, all tools, supplies and provisions have to be brought from far away. --- The relation to the Chilean authorities is very good. Weak points in the organization are: communications and personnel. --- La Silla has neither telegraph nor telephone connection. By means of their own radio telephone emitters and receivers ESO has created a provisional connection Santiago–La Serena–La Silla. --- One can imagine what delays and misunderstandings may arise when passing on technical and sometimes complicated messages to collaborators of different nationalities ---. Personnel problems arise partly from these poor connections. Obviously [these] are unavoidable for an organization manned with Dutchmen, French, Belgians, Germans, Swedes and Chileans ---. Difficulties were also encountered with young astronomers, coming from the intimate European academic circles and transferred to the loneliness of an almost uninhabited desert. Some of these lack the pioneering spirit of their elder colleagues ---. For this problem, too, the ESO Direction may well find a solution in due course. --- The ambitious and daring project --- develops favourably ---.*"

By the end of 1967, Camp Pelícano had been extended with several facilities including a clubhouse and a soccer field for the personnel. On La Silla, a Camp had been added for the personnel of the construction firms, and the buildings for the 1-m, 1.5-m and Schmidt telescopes were almost completed as well as the heating plant. Construction of the GPO building had been started again after a lengthy interruption due to road constructions in the neighbourhood. Also the building for the first of the "national telescopes" (about which we will have to tell more below), the one of the Bochum Observatory, was completed except for the mounting of its dome. For the purpose of measuring atmospheric temperature fluctuations by the method devised by Siedentopf (and described in article II), a second 24 m high mast had been erected on the secondary summit of La Silla in addition to one on the highest top which had been erected in 1966. Supervision of the construction work had been taken over from the retiring engineer H.O. Voigt by his successor Raul Villena per August 1, 1967.

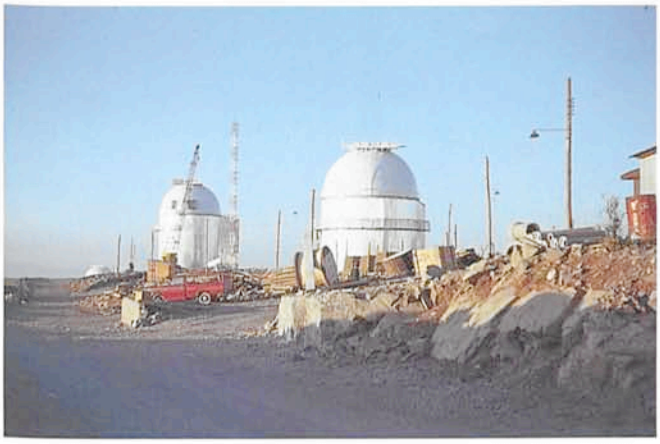
Astronomical activity with the 1-m telescope in its provisional dome had been well under way throughout the year. In Santiago, concrete foundations for the Headquarters and the connected mechanical workshop were partly finished.

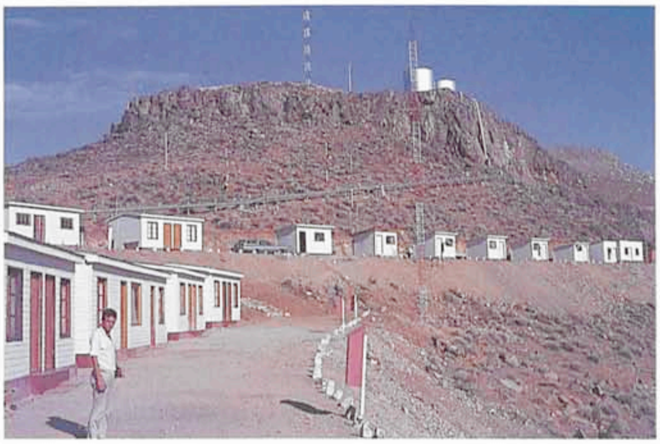
In the course of the next year, 1968, almost all elements on La Silla assumed their intended functions. The 1-m telescope was transferred from the provisional dome to its definitive one in September, the 1.5-m telescope was installed in its dome in the middle of the year, the GPO was put into operation in June, and an aluminizing plant was installed in the building of the 1.5-m telescope [3]. The Bochum 60-cm telescope was installed in September. Preparations were made for the erection of the building for a second "national instrument", the 50-cm Danish photometric telescope (see below). The Hostel was finished and became available for those, staff and visitors, who during those early years had had to be satisfied with the provisional huts, dining rooms,



MAY 1967, CONSTRUCTIONS ON LA SILLA

Left photograph: *The building for the 1.5-m Spectrographic Telescope taking shape. In the foreground, left, part of the provisional dome for the 1-m Photometric Telescope.*
Right photograph: *Construction of the Hostel. Both photographs from slides by the author.*





LA SILLA, DECEMBER 1967

Left photograph: *Buildings and domes for the Spectrographic Telescope (left) and the Photometric Telescope (middle) nearly completed, as seen from a site near the GPO.*
Right photograph: *La Silla's earliest Residential Quarters, Office Buildings, Catering Facilities for night- and day workers, etc., located on the western mountain slope, beneath the water tanks and near the Schmidt Telescope building. Both photographs from slides by the author.*

etc. – they had been primitive, yet not unattractive for the pioneering-minded.

A very important improvement of the operations was the conclusion of a contract with the Chilean national communication system ENTEL by which La Silla was incorporated in the national telephone system in exchange for ESO allowing ENTEL to place one of its relay stations on La Silla [3]. From that moment on, the Observatory felt considerably better integrated with the rest of the world.

In 1968 also the road on the summit area was extended to the top where ultimately the 3.6-m telescope was to be placed. Moreover, in order to create sufficient space on this site, the top was lowered by about 9 metres [3]. This enlargement of the area was found necessary because a geological fault across the site had been detected, limiting the space of the telescope foundations to either the one or the other of the two approximately equal parts.

The Santiago Headquarters

Meanwhile, an important development had taken place in Santiago: the creation of the ESO Headquarters building. The ESO Convention contains no mentioning of a Centre or Headquarters in the country where the Observatory is established, nor is there reference to it in the Convenio, the agreement between ESO and the Chilean Government. Yet, from the beginning of its activities in Chile, ESO planned it, in Santiago, besides the main facilities on La Silla and the Office in La Serena. Before we follow the realization of this project, it is useful to have a brief look at the philosophy behind it, the more so because the role of the Santiago establishment was drastically reduced in the second half of the 1970's.

Already during the site testing in South Africa, the question of the infrastructure of the Observatory was occasionally taken up by the ESO Committee, although not to the point where basic decisions were to be taken, for the switch to South America became more and more a reality. Nevertheless, it was the concensus of opinion that ESO would have to create, besides its Observatory in the Karroo desert, a centre in or near the city of Capetown at a distance of some 300 km. Such a centre would serve for entertaining contacts with Government authorities, for transport services, and almost certainly also as a base with offices for administration and staff scientists and with technical laboratories from where much of the operation of the Observatory would have been conducted. A serious drawback for the operations on the sites tested, particularly of the one at Zeekoegat, would have been the remoteness from centres with sufficient educational and cultural facilities to make employment attractive for staff members with families coming over from Europe. Capetown seemed the natural candidate for such a centre. Thus, in the report on their visit to South Africa in August–September 1962, Fehrenbach and Heckmann wrote: *"– – – Nous sommes convaincus que l'établissement de l'Institut à Capetown est non seulement parfaitement possible, mais très indiqué – – –. Les possibilités de la ville de Capetown sont considérables. – – –"* [4].

Transferring this structural aspect from South Africa to Chile, the choice was less obvious. The capital Santiago is at a distance from the Observatory about twice what Capetown would have been. With La Serena much nearer, it was clear that here the base for the building activities had to be established. But should it also serve as a base for the scientific and technical staff, and hence become the staff's residential area?

At this point let me briefly refer to a somewhat connected aspect of ESO's role in European astronomy about which opinions were not always unanimous: should ESO become a scientific institute in its own right – or should it rather be what our French colleagues used to call an *"Observatoire de mission"*? By this we mean, a facility of which the function is basically to serve astronomers from the participating institutes to collect observational data which they then carry home for further analysis. The Convention is not explicit on this point; in its preamble it speaks of *"creating an observatory equipped with powerful instruments – – – and accordingly promoting and organizing co-operation in astronomical research"*. Co-operation only in running the facilities – or also in the joint effort in the study of the heavens? The same uncertainty is encountered in the initial historical statement of 26 January 1954 reproduced in my first article.

I may have occasion to come back later to this recurrent matter of policy. In the present context we note that in the 1963 stage of planning a Centre called Headquarters was foreseen in Chile including among other items: a large lecture room, many offices for astronomical staff besides those for visiting astronomers, a rather complete library, photographic services, etc., clearly suggesting a research centre of considerable scope. (See, again, Ramberg's article in *ESO Bulletin* No. 2 referred to before.) But, where to build this Centre?

SEPTEMBER 1968, MOVING THE 1-m TELESCOPE

In September 1968 the 1-m telescope could be moved to its permanent dome. Dismantling it and taking it out of the provisional dome required taking the latter apart, for the slit was too narrow to let telescope and base through.

Left-hand photograph: *The telescope tube hangs on the crane, in the foreground left the provisional building and in the right foreground the dome. In the background the building of the Bochum Telescope.*

Right-hand photograph: *Telescope tube and base on their way to the new dome.*

Photographs by Eric Maurice in the ESO Historical Photographs Archives.

At the July 1963 meeting of the ESO Committee, in the context of the report on the visit of some Committee members to Chile (the "Summit meeting" described in article III), its Chairman is quoted mentioning that "*– – – AURA is setting up its Headquarters in La Serena. In this little town few English speaking people are living; yet is has a small English school. Santiago offers better possibilities for cultural life; it has two good French schools, two German, one English, and one Swiss school. – – –*"

The matter was discussed again on January 20, 1964, on the occasion of an informal preparatory meeting of the ESO Committee (preceding the meeting with representatives of AURA and CARSO mentioned in article III). The Directorate referred to the better contacts with Government authorities, embassies and representatives of international firms in Santiago, and to the advantage of the presence of universities and European schools. On the other hand, the importance of La Serena as a centre for the co-ordination of constructions was obvious and there was the important fact that AURA established here its Headquarters. According to the minutes "*The discussion converges towards the opinion that the ESO Headquarters should be located in Santiago and an ESO supply office should be erected at La Serena. – – –*" [5]. A decision was postponed until more experience would have been collected in Chile. Yet, the decision in favour of Santiago was taken already at the second Council meeting, in May 1964. The minutes report that, after discussion of the various arguments mentioned before, and in particular upon the expression of preference for Santiago by the previously hesitant French delegation, the decision was taken unanimously.

The Vitacura Donation

Meanwhile, for the Council meeting of May 1964 the Directorate had prepared a presentation of various offers for land in the Santiago area [6]. However, shortly after this, in August 1964 the Chilean Ministry of Foreign Affairs generously suggested that ESO might receive as a donation state-owned grounds in Santiago. These grounds were adjacent to the United Nations building in the Vitacura district, an attractive and prestigious location. By letter of September 18, 1964 the Chairman of the Finance Committee authorized the Director to react positively, and after study of the proposition from architectural and technical points of view and an extensive series of internal Chilean legal steps [7], the contract between the Chilean Government and ESO was signed on October 30, 1964 [8].

The donation concerned an area of about 3.4 ha. Conditions from Chilean side were only that no residential buildings should be included, and that realization should start within one year after the signing of the contract. For purposes of architectural harmonization, consultation took place between ESO's architect de Vlaming and the architect (Duhart, a pupil of Corbusier) of the adjacent UN building – one of quite unorthodox design. By the time of the dedication of the road on La Silla, March 1966, the architectural designs had been completed [9]. Construction began early 1967, and at the time of the 1969 dedications the building was just ready to receive ESO's guests and start its function in science and administration. It was of simple, yet distinguished style, fitting the representative aspect of its future intended role.

The National Telescopes

Returning now to La Silla, we must first report on an originally unforeseen element.

The intermediate-size telescopes described in article IV and erected on La

Silla in the second half of the 1960's, as well as the Schmidt and the 3.6-m telescope that would follow later, all belonged to the Initial Programme defined in the ESO Convention. The term "Initial" indicates that beyond these, at some stage in its development, ESO might wish to add other instruments. What one had in mind were instruments of different properties but having the same status as the earliest ones. A small addition of this kind was realized in the year 1971: the 50-cm photoelectric telescope, not only because of the need for such observational data but also because it was to serve for trying out automation designs in the development of the large Telescope [10]. It was a duplicate of the Copenhagen 50-cm national telescope put on La Silla in 1969 as described below, and it became part of the regular budget.

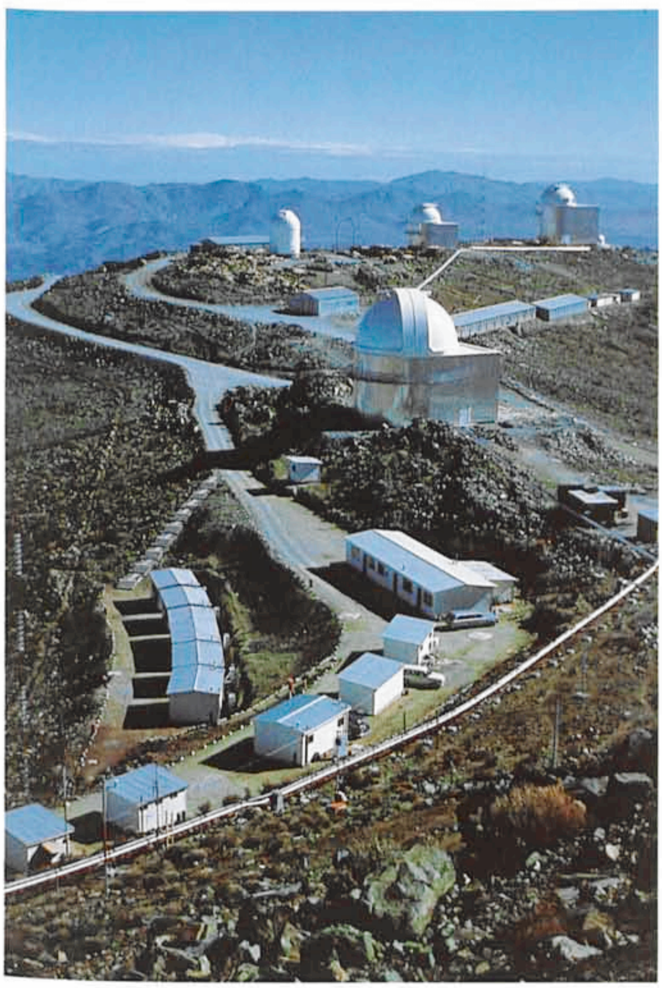
However, an extension of the telescope park not foreseen in the early days constituted the so-called national telescopes. They may be defined briefly as telescopes which are the property of one of the member states or, even narrower, of an institute in one of these states and placed on La Silla, making use of La Silla's favourable climatic conditions and logistic facilities, and for which, as a compensation for ESO's services, ESO then obtains a certain fraction of the observing time. In practice, ESO as a rule has provided the building for the telescope, with or without the dome. In the course of time these telescopes have become an important and, from the point of view of the community of observers, virtually integral part of the ESO facilities. In the following I shall briefly review their early history: by the time of the dedications in 1969 the first proposals of this kind had already been realized.

The First National Telescope: the Bochum 60-cm

The first proposal for such a telescope was an initiative of the Director of Bochum Observatory, Th. Schmidt-Kaler, discussed by Council in its meeting of November 1966 following pre-discussion in the FC. The telescope, meant for photoelectric work, was to be acquired with financial support from the Deutsche Forschungsgemeinschaft (DFG), the national science foundation of the German Federal Republic. Accordingly, partners in the negotiations were ESO, the DFG and Bochum University. In his presentation of the proposition to Council, Heckmann placed it from the outset in the context of possibly having more such additions to the ESO facilities. The Bochum proposal was in principle approved at the same Council meeting, but the contract between the three parties in its final form signed only in 1969 after successive approximations [11]. Principal conditions of the contract were that ESO would be granted 30 % of the observing time, that apart from the telescope, the DFG also paid for the dome, and that neither of the parties would terminate the agreement within 20 years.

Meanwhile, the building for the Bochum telescope was completed in 1967, and equipped in April 1968 with a prefabricated dome as had also been done for the preliminary housing of the 1-m telescope. Contrary to what was done for later national telescopes, the Bochum building included dormitory facilities for the observers. The telescope was installed in September 1968. A description, including the Bochum photometer, has been given by Th. Schmidt-Kaler and J. Dachs in *ESO Bulletin* Nr. 5 of December 1968.

Already on the occasion of this first Council discussion, in November 1966, there was reference to two other potential proposals. A. Reiz, attending the meeting as "observer" on behalf of Denmark that would join ESO in August



OVERVIEWS OF LA SILLA, 1968

Left photograph, June 1968: *Taken from near the water tanks, from foreground to background: the provisional Residential Area, the Schmidt telescope building, and, from left to right, buildings of the GPO, the 1-m, and the 1.5-m telescopes.*

Right photograph, October 1968: *Aerial photograph taken from the South-West. From left to right: the buildings of the 1-m, the 1.5-m, the provisional 1-m, and the Bochum telescopes, and the Hostel. In the foreground before the Hostel, site preparation for dormitories. This photograph may be compared to the one taken from the same position in October 1966, shown on page 30 of the previous article. Both photographs by Eric Maurice in the ESO Historical Photographs Archives.*

MEALS IN OLD AND NEW AMBIENCE

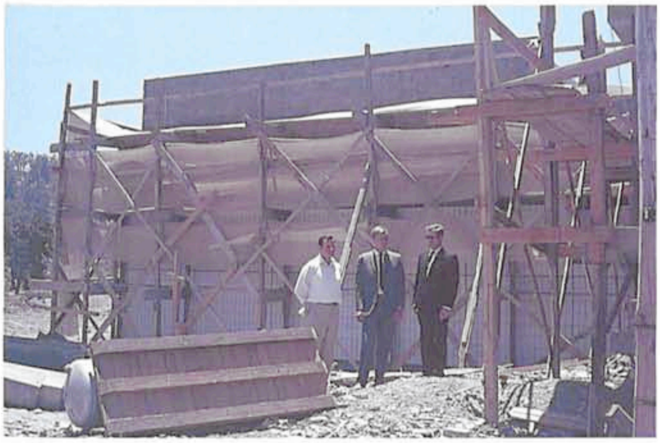
Left photograph: *May 1967; Kapteyn Laboratory observers M. de Vries and R. Mulder, with ESO's mechanic J. Doornenbal, relishing a meal in the provisional restaurant.*
Photograph from a slide by the author.
Right photograph: *January 1969; Tea-time in the new cafeteria. At the foreground table from left to right: Albert Bosker, anonymous, J. Palisson, Hans-Emil Schuster and A. Siméon.*
From the ESO Historical Photographs Archives, in collection marked "January 1969 von Dr. Muller".

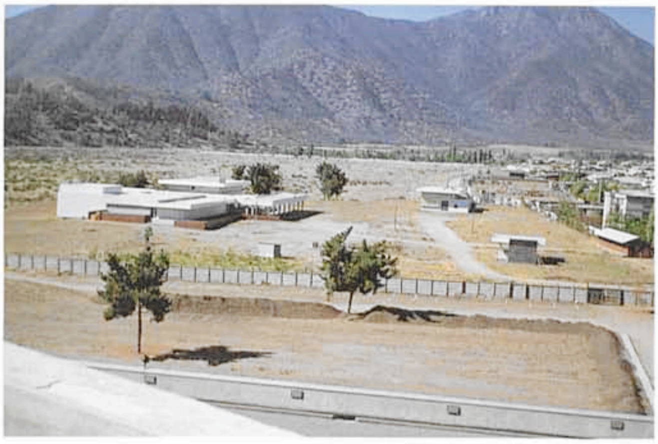
1967, expressed the hope that a national 1.5-m Danish telescope, still in the planning stage, might be put on La Silla, and there was also reference to a (distant) possibility that Uppsala Observatory might move the Schmidt telescope it had in 1957 installed at Canberra, Australia, to La Silla – a proposition that was never realized. We shall return later to the Danish 1.5-m telescope.

The Danish 50-cm Telescope

The second national instrument installed was the 50-cm photoelectric telescope belonging to Copenhagen Observatory. Early consultations with the Director of ESO led to a proposal for the Council meeting of December 1967, just after Denmark's joining ESO. At that time, the telescope was meant to be temporarily only on La Silla, for a specific programme, and it therefore was first, in February 1969, installed in the provisional building of the 1-m telescope after the latter had been moved into its proper dome. However, already in the course of 1968 Council agreed in principle to install the telescope on a more permanent basis, which led to first draft contracts between ESO and its

Following the dedication ceremonies in March 1969, the German Minister of Education, Dr. Gerhard Stoltenberg, visited the ESO Guesthouse where he made acquaintance with members of the ESO staff and their wives. In these three photographs Director General O. Heckmann introduces to Dr. Stoltenberg from left to right: Mrs. Ursula Villena, Raul Villena, Harold Hyslop; André Muller and Johan Bloemkolk; Mrs. Louise Muller and Mrs. Olga Hyslop.
From a series of photographs in the ESO Historical Photographs Archives.





THE HEADQUARTERS IN THE VITACURA SUBURB OF SANTIAGO

Left photograph: *December 1967, the construction stage visited by Victor Blanco (left) and Jürgen Stock (middle) of AURA-Cerro-Tololo, with Raul Villena of ESO.*
Photograph from slide by the author.
Right photograph: *December 1968, view of HQ from the roof of the adjacent United Nations building: main building of HQ is to the left of the middle of the photograph.*
Photograph by Eric Maurice in ESO Historical Photographs Archives.

owner of 1968 [12]. The agreement in its final form between Copenhagen University and ESO was signed only in 1975, simultaneously with that for the Danish 1.5-m telescope [13]. For the housing of the telescope a new dome was built, identical to the one for the ESO 50-cm instrument. These buildings were finished in 1972 and in it the telescope became operational again in 1973.

The Danish National 1.5-m Telescope; Basic Considerations

It would take many years until the next national telescope would be installed: the Danish 1.5-m. (A 40-cm telescope with its housing and adjacent office space was installed in 1975 by the Geneva Observatory; however, as Switzerland was not yet a member state of ESO at that time, its status was different from that of the telescopes discussed here.) The Danish 1.5-m was the subject of an application by Reiz and Strömgren of 9 November 1968 [14] which was accepted in principle by Council in its meeting of June 1969. However, the telescope became operational only a decade later, in October 1979, an epoch well beyond the period covered by this series of articles. Council's approval in 1969 must be seen in the context of far reaching proposals for extensions of the telescope facilities submitted in the year 1968 by the Scientific Programmes Committee, a committee installed in December 1967 and to the activities of which I shall return in the next article.

It was this Danish telescope that in an early stage evoked more thorough discussion of national telescopes in general than Council had devoted to them in the beginning. This started at the December 1968 meeting and continued at the meetings of March, June and December 1969. In these discussions the French delegation, whereas it fully supported the acquisition of the Danish telescope, stressed the importance of formal aspects such as the question whether these telescopes would fit within the ESO Convention and the Convenio with Chile, it warned for overcrowding on La Sillla, and insisted on careful selection of such telescopes and certain scrutiny of their observing programmes, and study of the financial implications. The first French remarks were added as an addendum (by P. Lacroute) to the minutes of the December 1968 Council meeting [15].

Further discussion was based on two documents: "Instruments étrangers implantés à La Silla; Essai d'évaluation de la valeur de la contribution de l'ESO" [16] prepared by the French delegation, and one by the ESO Directorate: "General Conditions for Admission of National Telescopes on La Silla" [17]. The laborious discussions, at which the French delegation took the view that national telescopes should be considered in the category of Supplementary Programmes as defined in the Convention (see my article I) – did not lead to a clearcut policy for future applications. It had fallen into the background by the time when, years later, the matter of national telescopes became of interest again. However, the discussions were symptomatic for growing concern among Council with regard to developments in ESO. In the next article we will return to these worries. For the moment we will forget about them, just as Council did – superficially at least – when it proceeded to Chile for the festive dedications . . .

The Dedications

On their way to Chile, Council on March 17, 1969 paid a visit to AURA's Kitt Peak National Observatory near Tucson, Arizona. Confrontation with this observatory, of comparable size to what ESO intended to become, naturally should be instructive, and was prompted by a history of mutual collaborative attitude and AURA's counsel in ESO's instrumental developments. AURA's President W.A. Hiltner and Kitt Peak Director N.U. Mayall were, in turn, guests at the ESO ceremonies in Chile.

Council arrived in Santiago on March 19 and acquainted itself that same day with the Headquarters in Vitacura. The next day it visited the Guesthouse, enjoyed the swimming pool and a reception by the German Minister of Education Dr. G. Stoltenberg, and on March 21 visited Cerro Calan Observatory and its Director Claudio Anquita followed by a general reception at ESO Headquarters. On March 22 a full-day Council meeting took place there. On March 23 Council flew to La Serena and visited this town and its surroundings, and on March 24 it went by bus to Pelícano and next to La Silla. Council members stayed in the Hostel and visited the many installations in operation: telescopes, workshops, powerplant, storerooms, dormitories, etc. On March 25 the inauguration ceremonies described in the beginning of this article took place. On March 26, Council paid a visit to Cerro Tololo Interamerican Observatory, and after having spent the night in La Serena, they flew back to Santiago on March 27 [18].

The Dedication Symposium on the Magellanic Clouds

The dedications also induced ESO to organize its first broad scientific symposium at the Headquarters in Santiago on March 28 and 29. Subject were the Magellanic Clouds, one of those objects of research at which ESO had aimed from its very beginnings. Participants came from Argentina, Australia, Chile, Mexico, South Africa, the United States and, naturally, from the ESO member states. The Proceedings of the symposium, edited by André Muller, were published in 1971 [19]. The symposium underlined ESO's taking up its tasks in astronomical research – although at that time modest observing programmes had been underway with the first telescopes, as we shall see in the next article. An early report on the subjects discussed at the symposium was given by Bengt Westerlund in *Sky and Telescope* of July 1969 (Vol. 38 No. 1).

References and Notes

Abbreviations used:
EC = ESO Committee, the committee that preceded the ESO Council.
EHA = ESO Historical Archives. See the description in the *Messenger* No. 54 of December 1988.
EHPA = ESO Historical Photographs Archive.
FHA = *Files belonging to the Office of the* Head of Administration of ESO.

[1] EHA-I.A.2.14.
[2] Frank Middelburg became an ESO employee in 1967. By the time of his untimely death in the year 1985 he had become a specialist in the fields of image processing and software systems. See the obituary by A. Ardeberg in the *Messenger* No. 42 of December 1985.
[3] See the ESO Annual Report for 1968.
[4] A copy of this report occurs in the Oort Archives of the Leiden University Library; a duplicate from this has been put in EHA-I.A.1.18.
[5] EHA-I.A.1.22.
[6] Cou. Doc. Chi-7 in EHA-I.A.2.14. and minutes of the 2nd Cou Meeting.
[7] Cou. Doc. Chi-12 and 14 in EHA-I.A.2.14. and letters of Heckmann to Oort of 4 and 13 Oct. 1964 in EHA-I.A.2.10.
[8] ESO Basic Texts, Section B4.
[9] See the sketches included in the Annual Report 1965.
[10] See, for instance, Ann. Rep. 1968, p. 10. The realization of this telescope became part of the task of the ESO TP-Division.
[11] See FHA File 2.9.2. The last one of the signatures was on Sept. 11, 1969, by the Chancellor of the Un. of Bochum.
[12] See FHA File 2.9.3.
[13] See Doc. Cou-205 of Nov. 7, 1975 in FHA File 2.9.3.
[14] See Council Minutes December 1968.
[15] "Problèmes posés à l'ESO par l'implantation sur ses terrains d'Instruments étrangers".
[16] See Minutes 13th Cou Meeting, p. 12.
[17] Cou-doc No. 55 of May 30, 1969 in FHA 1.1.1/1.2.1.
[18] Details of the programme of the Council visit are in EHA-I.A.2.16. See also B.E. Westerlund's report in *Sky and Telescope*, Vol. 37, No. 6 of June 1969.
[19] A.B. Muller, ed., *The Magellanic Clouds*, Astrophysics and Space Library, Vol. 23, Reidel Dordrecht 1971.

REPORT ON THE FOURTH JOINT ESO/CTIO COLLOQUIUM

"The 1001 Nights of SN 1987 A"

Compiled by P. BOUCHET, ESO

1. Introduction

The fourth joint ESO/CTIO colloquium was held at La Silla on November 20, 1989, in order to celebrate properly the results of the 1001 nights spent after the outburst of SN 1987A. This colloquium consisted of informal talks followed by debates and a round-table discussion dealing with the acquired experience in a supernova follow-up, the current observations of SN 1987A, the future joint ESO/CTIO monitoring of SNs, and the preparation for the next bright supernova(e?) (observations in Chile).

Most of the staff astronomers and visitors from the three observatories of the IVth region of Chile (La Silla, CTIO, Las Campanas) were able to attend the meeting, which largely contributed to its success.

The colloquium ended in the gymnasium of La Silla where the ESO Astronomy volleyball team brilliantly defeated the CTIO one, in an intense game. To conclude in the very best way this pleasant and fruitful day, a cocktail was then offered to everybody.

We present in the following a summary of the talks given during the meeting.

2. VISIBLE SPECTROPHOTOMETRY: Mark M. Phillips/CTIO

SN 1987 A in the Large Magellanic Cloud has provided a unique opportunity to study the spectral evolution of a Type II supernova. Taking advantage of the superb observing conditions that characterize the "Norte Chico" of Chile, astronomers at ESO and CTIO have led the way in obtaining precise spectrophotometry of this important object at visual wavelengths. These observations have yielded a number of important findings, a few of which are listed below:

2.1 Abundance Anomalies in the Hydrogen Envelope

The first spectra obtained of SN 1987 A were characterized by strong H and He P-Cygni emission lines. Attempts to model these early spectra have suggested that the helium abundance in the outer envelope of the supernova may have been as much as a factor of 2-3 times the solar value. As the supernova expanded and cooled over the following weeks, strong ab-

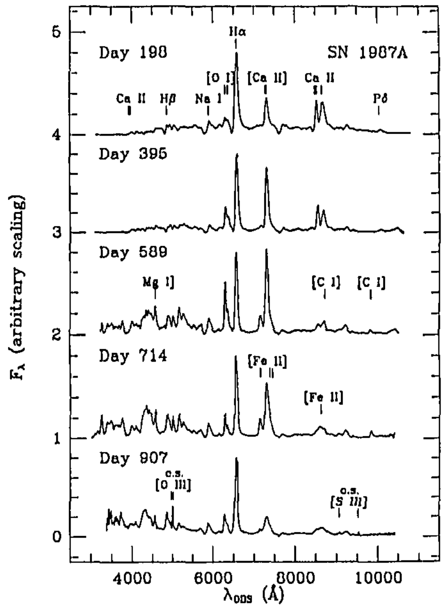


Figure 1: *Selected optical spectra of SN 1987 A obtained at CTIO which illustrate the evolution from days 198–907. Identifications of the most prominent emission and absorption features are indicated. The narrow [O III] and [S III] lines visible in the spectrum for day 907 are due to the circumstellar material that surrounded the progenitor Sk -69202.*

sorption lines of Ba, Sr, and Sc were observed, indicating similar enhancements of the s-process elements. These findings suggest that the progenitor of SN 1987 A, Sk -69202, may have undergone a phase where the products of a He-burning shell were mixed in significant quantities to the surface.

2.2 The "Bochum Event"

Approximately three weeks after the outburst of SN 1987A, two emission "bumps" appeared in the blue and red wings of H-α and several other emission lines. It seems likely that these bumps were the first observable consequence of the arrival, at the photosphere, of energy associated with the radioactive decay of ^{56}Ni and ^{56}Co. For this to have occurred less than a month after outburst implies significant mixing of radioactive material outwards into the hydrogen envelope.

2.3 [Fe II] Emission During the "Nebular" Phase

Emission lines of [Fe II] became clearly visible in optical spectra of SN 1987 A around 200 days after outburst, growing in strength until approximately day 650 (Fig. 1). Forbidden emission lines of Fe, Ni, and Co were observed in the infrared at approximately the same time. These observations represent the first unambiguous detection of the products of explosive nucleosynthesis in a type II supernova.

2.4 Emission Line Profile Variations

At the beginning of the nebular phase (day 200 or so), the peaks of the H I, Na I, Ca II, and [Fe II] lines all displayed a prominent redshift, apparently due to scattering by electrons in the hydrogen

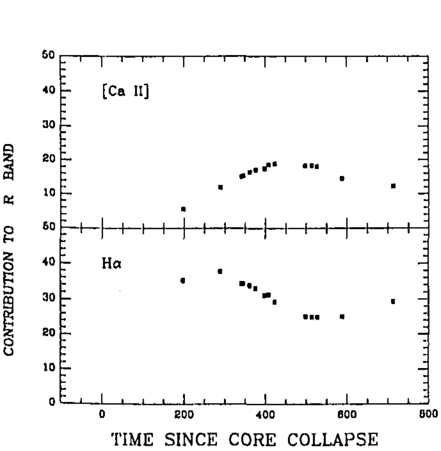


Figure 2: *The contribution of the Hα (lower panel) and [Ca II] 7291, 7323 (top panel) emission lines in SN 1987 A to the flux in the CTIO R band, plotted as a function of time.*

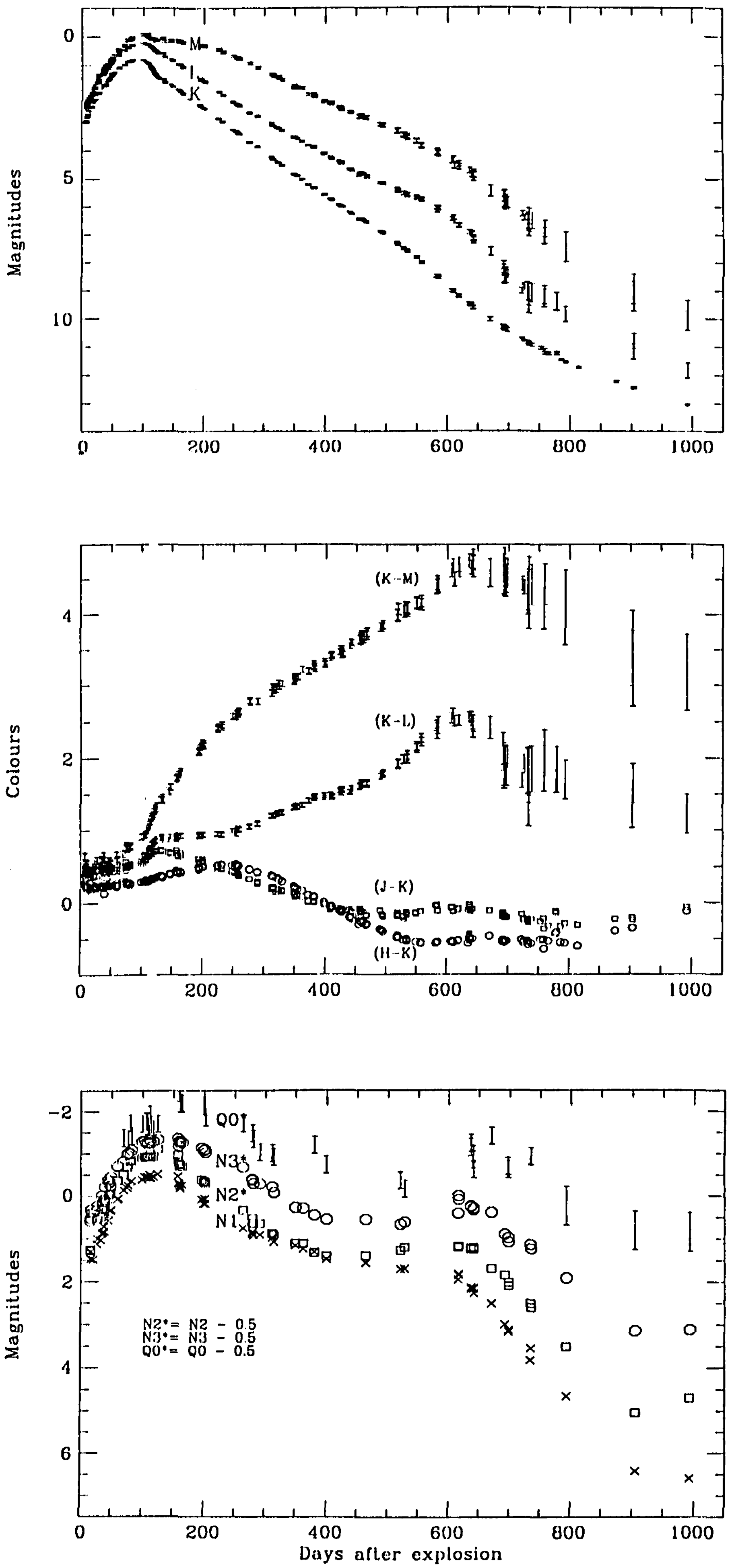


Figure 3: *The lightcurves in the broad band filters, as indicated.*

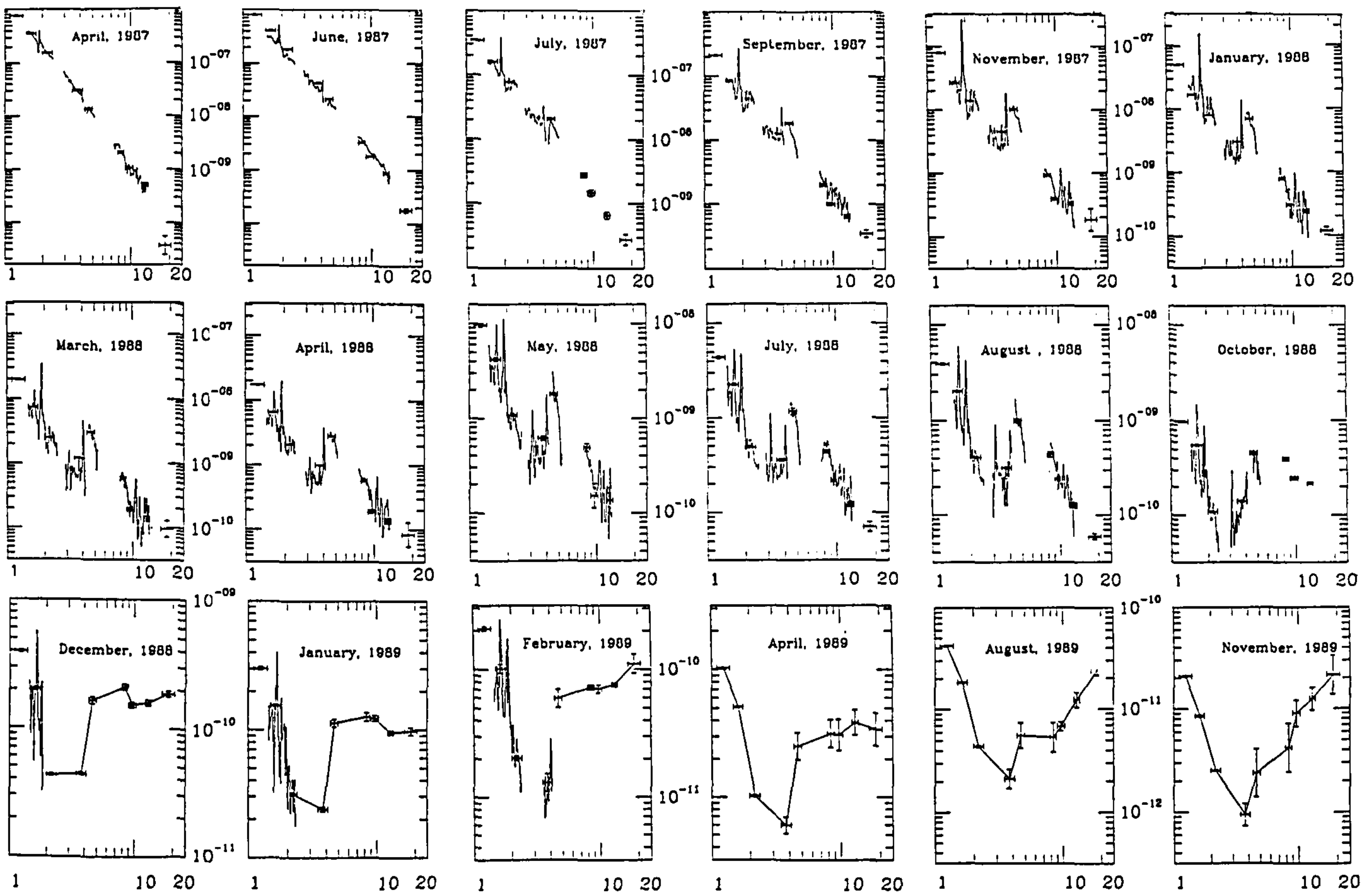


Figure 4: *The evolution of the spectral energy distribution from 1 to 20 μm deduced from ESO broad band photometry, and the evolution of the spectrum obtained through CVF filters, for the indicated dates (X-axis: wavelength in μm; Y-axis: flux density in erg s^{-1} cm^{-2} μm^{-1}).*

envelope. The peaks of the [OI] 6300, 6364, [CaII] 7291, 7323, and [CI] 9824, 9850 lines lacked such a redshift during the same period, proving conclusively that these emission lines originated in a physically distinct zone. Between days 525-590, however, the peaks of all of the observed emission lines underwent a sudden blueshift, coinciding nearly exactly in time with the development of a far-infrared excess in the flux distribution of the supernova. These two phenomena have been successfully interpreted (by ESO astronomers at first) as observable consequences of the formation of dust in the ejecta. Although the blueshifted peaks have persisted to the present, further changes have continued to occur in the profiles of at least some emission lines. Most prominent of these has been a broadening of the [OI] 6300, 6364 lines which occurred between days 700-800, the cause of which is not yet fully understood.

3. UBVRI PHOTOMETRY: Mario Hamuy/CTIO

Since the announcement of the outburst of SN 1987 A, the CTIO staff has undertaken a regular photometric monitoring of the Supernova. The data obtained have been used together with the ESO infrared observations to construct the ESO/CTIO bolometric light-curve.

Large discrepancies have been found between the observations of UBVRI photoelectric photometry of SN 1987 A carried out a CTIO and at SAAO. In order to clear up the origin of these differences we calculated synthetic magnitudes using different bandpasses from our spectrophotometric database. For this purpose we made laboratory measurements of the bandpasses used at CTIO, with which we were able to successfully reproduce the CTIO photoelectric photometry. On the other hand, the SAAO photometry could be synthetically reproduced using the standard Kron-Cousins band functions. We conclude that the discrepancies between both data sets are due only to the differences between the photometric systems used at both observatories. In addition, we found that the contribution of the emission lines in the spectrum of SN 1987 A to the R and I magnitudes is non-negligible for the purpose of transforming the broad-band magnitudes to monochromatic fluxes (see Fig. 2). The effect of the emission lines in the UBVRI photometry must be carefully taken into account when deriving the bolometric light curve of SN 1987 A.

4. INFRARED OBSERVATIONS: Patrice Bouchet/ESO

An infrared monitoring programme of SN 1987 A was started at La Silla on February 27, 1987, and is still going on. The observations carried out (at the 1-m, 2.2-m and 3.6-m telescopes) concern broad band photometry from J (1.24 μm) to Q0 (20 μm), as well as spectrophotometry in the four atmospheric windows (1.4–2.4 μm; 2.9–4.2 μm; 4.7–5.4 μm; 8–13 μm) with CVFs ($\lambda/\Delta\lambda$ ~80). The ESO team working on this programme include I.J. Danziger and L.B. Lucy from ESO-Garching and, familiar to all ESO infrared users, our observer R. Vega, whose active and enthusiastic participation has been crucial for the programme. T. Le Bertre and A. Moneti also collaborated for some of the observations.

Since we started this work, a large amount of observing time has been dedicated to it, resulting in the most complete set of such data ever collected on a supernova (including SN 1987A!). Figures 3 and 4 illustrate our results.

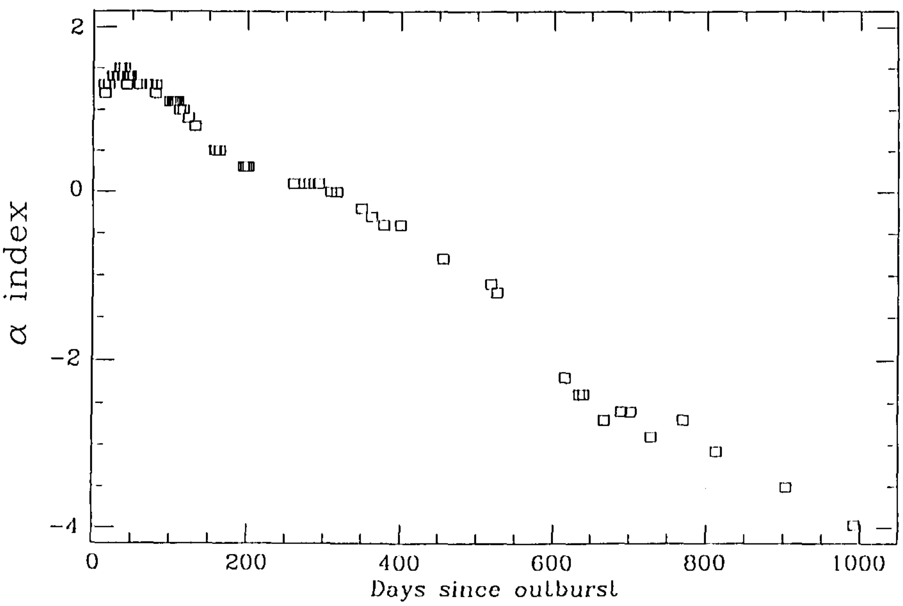


Figure 5: *The spectral index α as function of time.*

4.1 The IR Excess and Excess Emission at M

Even in the earliest photometry, there was a clear excess in the far IR. By day 100, an emission started to develop in the M band (4.8 μm), which was attributed to CO. By day 260, an excess appeared at N1 (8.4 μm), probably due to SiO. We define the infrared spectral index α by fitting from L (3.8 μm) to Q0, excluding M and N1, the function:

$$F_\nu = F_0 \nu^\alpha$$

Figure 5 shows the evolution of the α index: it started near the Rayleigh-Jeans law (α = 2) and decreased rather uniformly. Such a continuous temporal variation argues for a single physical cause, the most obvious explanation being the *early* and continuous formation of dust (starting at about day 100). However, with these data alone it is not possible to rule out that several effects may have conspired to produce the uniform variation. The IR excess till day 300 could be due just to the gradual transformation from a dense and optically thick plasma radiating like a black body to a low density optically thin plasma radiating by free-free emission (α = 0). Indeed, α leveled out a 0 between days 200 and 300. After that time, α resumed its decrease as a cool component appeared.

4.2 The Thermal Component

Around day 550, our broad band photometry reveals the emergence of a cool component (Fig. 4). When the thermal emission rapidly dominated the total observed flux, the optical magnitudes began to accelerate their decline in brightness. (U-V) decreased roughly uniformly while (V-K) suddenly changed evolution from blue to red, even though there has been no corresponding change in the bolometric lightcurve (see next section). The simultaneity of these events can be most easily explained by the formation of dust (or the accelerated formation of dust, if the early IR excess is due to dust) local to the Supernova. The ESO team (Danziger et al. 1989, and Lucy et al. 1989, 1990) were first to announce and discuss the formation of dust in the ejecta of SN 1987 A. These authors have estimated the dust extinction in various optical emission lines, and using these line optical depths, have shown that the inflection in the V lightcurve at around day 500 can be modelled by a simple extrapolation of this lightcurve from the linear decline phase, reddened according to the estimated extinction from the emission lines. They have also shown that the line optical depths appear to provide evidence for selective extinction.

4.3 The Bolometric Lightcurve

The CTIO UBVRI photometry together with the ESO infrared photometry have been used to derive the bolometric lightcurve (Suntzeff and Bouchet, 1990). In order to estimate the luminosity of the thermal component (discussed in the previous section) a black body fitted between L and Q0 (with an interpolation at M to avoid the contamination by CO) has been integrated up to zero frequency. Since the actual flux in the far IR is probably a combination of line emissions *and* thermal re-radiation from dust, the estimated total flux from the fits is an *upper* limit to the thermal radiation. The resulting bolometric lightcurve (the only one available which takes into account the measured infrared flux up to 20 μm), is by now well known and understood (see the curve on page 41 of this issue of the *Messenger*) as follows:

- During the first 10 days the high temperature plasma produced by the passage of the shock, cooled to a temperature typical of hydrogen recombination (T ~5500 K), which produces a rapid decline of the lightcurve.
- Between days 10 to 125, there was a slow brightening to maximum followed by a rapid decline as the hydrogen recombination front propagated inward into material that was being heated by radioactive decay of ^{56}Ni and ^{56}Co. At that time, the radioactive decay energy was trapped behind the hydrogen recombination front and produced both mechanical work in accelerating the plasma and later a diffusion wave of energy that was seen as the broad maximum (mixing of the radioactive material outward, and of hydrogen inward into the core). Note that the light curve slowed its rise around day 30 at the time when SN 1987 A began to be powered by energy released from the diffusion wave of thermalized radioactive energy, rather than the recombination of the hydrogen ionized purely by the shock, as discussed by M. Phillips in his talk (see also Lucy, 1988).
- Between days 125 and 800, the recombination front had passed through the diffusion wave of trapped energy, and the observed bolometric flux became due to the fraction of the radioactive energy from the decay of ^{56}Co that was thermalized by inverse Compton scattering.
- After day 800, measurements made in August and November 1989, showed a levelling off of the lightcurve. Subsequent observations made in December and January confirmed the reality of the levelling off. This result, and its interpretation as probably due to the presence of a pulsar, has been communicated recently in I.A.U. Circular 4933 (January, 1990) and the ESO Press Release PR 01/90. It is presented in this issue of the Messenger (page 41).

In conclusion, the main results concerning the ESO/CTIO bolometric light curve are:

At least up to day 800:

The sum of the observed flux (between 3200 Å and 20 μm) with the observed high-energy flux as fit by the models, is consistent with SN 1987 A being powered purely by the decay of ~0.07 $M_\odot$ of ^{56}Co.

No more than 30 % of the thermal flux can be due to an infrared echo without violating the energy budget. Any pulsar, IR echo or radioactive source other than

^{56}Co must have a luminosity inferior to 1.5×10^{38} erg s^{-1}.

At least from day 900 on, the bolometric lightcurve lies above a linear extrapolation from earlier epochs, which implies that a hitherto undetected energy source started to contribute significantly to the total energy output.

4.4 The Spectrophotometry

The infrared range is perfectly suited for spectroscopic studies of supernovae: in fact, whereas optical emission lines are strongly temperature and density dependent, the infrared forbidden line fluxes depend only weakly on temperature (for $T \gtrsim 1000$ K). In addition, for several years after the explosion, the densities in the ejecta exceed the critical densities of most of the fine-structure levels, so the line fluxes are independent of the density in the emitting region. Once the transitions become optically thin, the masses of heavy elements in the ejecta can be directly determined from the IR line fluxes. Moreover, the major IR continuum opacity in the H/He gas envelope is free-free absorption, which becomes small after several months. In the mantle, where the heavy elements are ionized, the total free-free optical depth is small at infrared wavelengths after ~6 months, and the formation of optically thick dust in the envelope produces a continuum (and alters the gas phase abundances in the ejecta). Our CVF spectra have been used to determine the masses of the heavy metals in the mantle, and particularly for ^{56}Co, through the observation of the [CoII] line at 10.52 μm.

The modelling of the spectrum leads to the conclusion that, at $t \gtrsim 1000$ days, an "Infrared catastrophe" should occur as the radioactive heating rate drops below the saturated, high temperature cooling produced by fine structure lines. At the time of this writing (January 1990) this "catastrophe" has not yet occurred.

5. SEARCHING FOR THE PULSAR: Christian Gouiffes/ESO

The duration of the neutrino burst detected by the Kamiokande and the IMB groups as well as its energy suggest that a neutron star was born after the explosion of the supernova SN 1987 A in the LMC. If the conditions are not too unfavourable (optical thickness too high or a pulsar beam not pointing in the direction of the earth for example) one might expect to detect optical pulses from the Pulsar.

We have started at ESO a continuous search in order to look for the possible emergence of this pulsar. The observations were carried out at different telescopes where the installation of a photometer was possible:

- The 3.6-m telescope and the Danish 1.54 were the most used.
- The acquisition programme allowed us a time resolution of 1 msec.
- The famous Crab Pulsar (which has a period of rotation of 33 msec and is bright enough to be detectable with certainty in a few seconds integration at the 3.6-m telescope) was observed when possible to check our acquisition programme.

After the announcement in January 1989 by Middleditch et al. (IAU Circular 4735) of the discovery of a nearly 2-KHz periodic signal from SN 1987 A, we modified our equipment in order to get a sample rate of 10 KHz. In February 1989, SN 1987 A was observed at the 3.6-m telescope. The data, which were immediately sent to Garching (Max-Planck-Institut für Physik und Astrophysik) to be analysed, did not show any significant signal, giving an upper limit of magnitude 20 for the pulsar (Ögelman et al., IAU Circular 4743).

We continue our monitoring at a rate of approximatively 1-2 nights per month. A Fast Fourier Algorithm developed by P. Grosbøl from ESO is used at La Silla at the Sun computers to have a quick look at the data a few hours after their acquisition and react immediately if something is wrong in the acquisition programme or in case we detect something . . .

At the moment of writing, no significant signal has been detected from SN 1987 A in the many hours of observations that we got. Even for this 1001 nights meeting no significant signal came out.

The recent infrared observations (P. Bouchet, this article) that show a levelling off of the bolometric lightcurve encourages us to continue our effort.

6. THE NEBULOSITY NEAR SN 1987 A: E. Joseph Wampler/ESO

Because the progenitors of type II supernovae were expected to be red supergiant stars, there have been a number of studies of the expected interaction of a supernova explosion on the remnant red supergiant wind (see Chevalier, 1987 for an early discussion of the SN 1987A situation and other references). Beginning on about day 80, narrow nebular lines were seen in IUE spectra of SN 1987 A (Wamsteker et al., 1987, Fransson et al., 1989). These lines grew in strength for about 400 days and then faded. This suggested that the supernova is surrounded by a thin nebular shell with a radius of about 400 light-days (~1.3 arcsec at the distance of the Large Magellanic Cloud). On about day 300 the optical continuum had faded sufficiently that nebular lines could be seen in the optical spectral region, and the extension of the nebular lines beyond the width of the supernova continuum spectrum indicated the presence of a small bright nebula, about 2 arcsec in diameter (Wampler and Richichi, 1989). It was already expected that the blue supergiant phase of SN 1987 A that occurred just before SN 1987 A exploded would produce a high density shell of shocked gas around the progenitor star. The UV flash that accompanied shock break-out in the first minutes of the explosion would then ionize the shell; the observed nebular lines are a signature of the recombining gas.

On August 29, 1989, UT, the NTT was used to obtain images of the supernova in conditions of 0.4 arcsec seeing; some of these were published in the December issue of the *Messenger*. A composite of more recent images taken on December 18 by Sandro D'Odorico and Massimo Tarenghi is shown here in Figure 6. We are indebted to them for permission to publish their data here. With the stellar images subtracted, it is seen that the nebula consists of three main structural components: an inner oval nebula, an outer filamentary loop north and south of the inner nebula and a "light echo" that is shaped like "Napoleon's hat" and extends to about 6 light-years to the north of the supernova. The inner structure of the nebula appears to be morphologically very similar to galactic planetary nebula.

It has been supposed that planetary nebulae begin during the red giant phase of a star's evolution, but that their complex structure results from an interaction between the red giant wind and the wind and radiation from the subdwarf nucleus (Balick, 1987; Balick and Preston, 1987). Because SN 1987 A never became a subdwarf and after its red giant phase it was only a blue giant for a short period of time these observations may prove useful for constraining models of planetary nebula formation. Even if the nebulosity around SN 1987 A is classified as a planetary nebula, it is not likely that SN 1987 A is the first observed supernova to explode inside a planetary nebula. Dickel and Jones (1985) have suggested, on the bases of modelling Tycho's supernova remnant, that Tycho's supernova (a type-I supernova) exploded inside a planetary nebula.

We are very fortunate to have had a nearby supernova explode in our lifetimes. At the present time the studies of the expanding envelope and the surrounding nebulosity can proceed independently, but soon the two will begin to interact and we can expect even more fireworks!

7. WHAT THE STORY TEACHES US: Patrice Bouchet/ESO

The following is certainly not intended to be a complete review of the subject (for this purpose, the reader may refer to Arnett et al., 1989 and Hillebrandt and Höflich, 1989), but rather a brief summary, from an observer's point of view, of the highlights of SN 1987 A. (Note that additional references can be found in these two reviews.)

7.1 The "Peculiarities"

The fact that the progenitor was a blue supergiant has certainly been the first surprise of SN 1987 A. However, it was already known before SN 1987 A exploded, that a low metallicity and/or an extensive mass loss could lead massive stars to such a blue phase. Only the effects of an appropriate mixing seem to have been studied after the explosion of the supernova. The blue appearance of the progenitor is probably due to these three interconnected effects, and it is therefore not considered anymore as an extraordinary characteristic of SN 1987 A, but rather as one possible road in the stellar evolution. However, it is worth noting that it is thanks to SN 1987 A that we are now aware of it!

The second surprise was the relatively low luminosity of SN 1987 A relative to other "normal" SN IIs: this has been explained as a consequence of the more compact structure of the progenitor. Moreover, as we have seen above, the bolometric lightcurve is perfectly interpreted in the same frame and with the same mechanism as those used for other SN IIs. In particular the role of the radioactive decay of ^{56}Co to power the lightcurve is a confirmation of the first suggestions made by Weaver and Woosley (1980).

It turns out, then, that the main "peculiarity" of SN 1987 A is that it could be seen! Selection effects (like extinction and distance) favour, indeed, the detection of bright explosions (in visible light). And, for instance, if the same supernova would explode near Cass A (which is closer but in a region of high extinction), it could only be detected as a neutrino emitter and (perhaps) as an infrared source. This leads one to question the present supernova rates.

The (relative) proximity and low extinction of this supernova allowed intensive and complete studies, which proved the absolute necessity of such observations in order to get a trustworthy picture of what was going on. For instance, the use of SN 1987 A to check the reliability of the absolute fluxes deduced from theory, showed that the models have to be quite sophisticated, and that a large amount of observational data has to be available. It now seems dangerous to use SN IIs as a kind of standard candles.

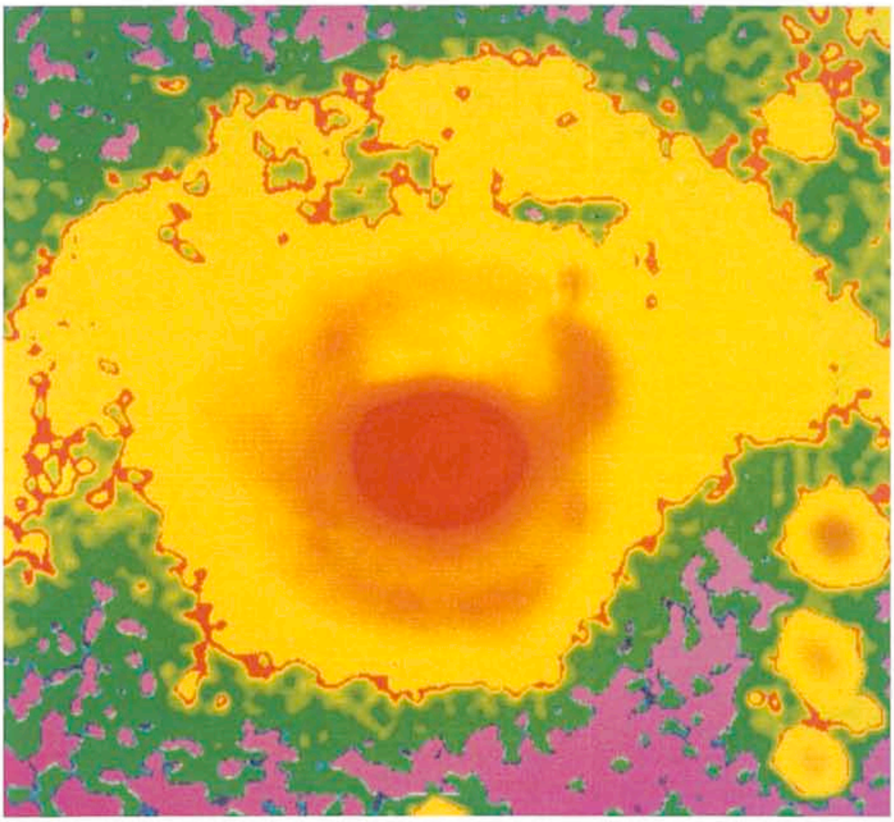


Figure 6: *A composite image in [OIII] and [NII] light of the nebulosity near SN 1987 A. The images were taken with the NTT by S. D'Odorico and M. Tarenghi on December 18, 1989. The images of SN 1987 A and its two field stars have been removed in order to show the nebular structure more clearly. North is up and East is to the left. The size of the figure is 14 × 13 arcsec.*

7.2 The New Concepts

The detection of the neutrinos a few hours before the explosion indicates the formation of a neutron star: this is the first direct evidence that this can really occur! These direct observations have been used to place new constraints on the fundamental properties of such particles (rest masses, lifetimes, magnetic moments, mixing angles, etc.), on important physical quantities such as the nuclear equation of state, and on the existence of exotic particles (axions and majorons). This is especially interesting as axions can be of importance in cosmology as candidates for the dark matter. However, although numerical simulations have reproduced the luminosity and the spectrum of those neutrinos, none could account for the energy balance of the explosion. Clearly, something is still missing in the current models.

Another important new concept introduced by the observations of SN 1987 A refers to the presence of an inhomogeneous mixing of shells of different chemical composition. In fact, mixing occurred:

- Before the explosion (induced by large-scale motions due to the rotation of the progenitor). This makes the academic dogma of an onion-shell-like structure (before the explosion) quite obsolete.
- During and after the explosion (due to Rayleigh-Taylor instabilities or to the expansion of hot bubbles of radioactive Nickel). This was realized because of the early detection of X and γ rays, the need to match the theoretical models to the observed bolometric lightcurve ("plateau"), and the interpretation of the visible and infrared spectra.

Finally, a major discovery was the detection by the ESO team of dust condensation in the metal rich ejecta with a clumpy distribution (Danziger et al., 1989, Lucy et al., 1989, 1990). One of the first implications of this discovery may be that the isotopic anomalies observed in meteorites can be explained in terms of dust of elementary and isotopic composition characteristics of the ejecta of a supernova which has condensed before being diluted into the primitive nebula of normal isotopic composition (Clayton, 1982). It seems then plausible that at least one supernova exploded in the vicinity of the proto-sun, some 10^6 years before its formation (Lee, Pappanasstassiou and Wasserburg, 1976).

7.3 The Open Questions

Although the appearance of SN 1987 A has led to new concepts as well as an extraordinary improvement in our understanding of type-II supernovae, some points remain obscure:

- The amount of dust condensed and its possible contribution to the total amount of dust in the galaxies. As pointed out by J. Wampler during this colloquium, the dust formed in the ejecta is expelled at great velocity and sooner or later will have to slow down, with a high probability of being destroyed.
- The enrichment of the circumstellar and interstellar matter in heavy elements (Danziger et al., 1990 were first to determine abundances and they show that there are large uncertainties in the quantitative estimates which are strongly model dependent).
- The stimulating role in star formation in dense interstellar clouds (Öpik, 1953; Herbst, 1977). Klein (1990) showed that the clouds could be destroyed in Rayleigh-Taylor time scales, and give rise to fragmented small clouds which could prevent star formation.
- The determination of H_o through a thermal interpretation at maximum visible light (Branch, 1977, found $H_o = 49 \pm 8$ kms^{-1} Mpc^{-1}). With the VLBI, Bartel (1990) estimated the distance to the LMC and deduced $H_o = 60 \pm 20$ kms^{-1} Mpc^{-1}, which in itself is not so new. However, Bartel stressed the point that he could get a far higher accuracy ($\sim$20%) by radio interferometry with Arecibo and VLBI.

On the other hand, some points traditionally related to the supernova phenomenon, or still speculative theories, have not received any input yet from SN 1987 A. Among them are the following ones:

- The relation between supernovae and phenomena observed in quasars;
- The acceleration of galactic cosmic rays in the shock wave fronts created by the explosion;
- The role of supernova induced star formation in producing and sustaining spiral structures in galaxies (Mueller and Arnett, 1976; Gerola and Seiden, 1978);
- The possibility that supernova explosions that took place during the first billion years or so after the big-bang (at a time when the galaxies we see today had not yet formed) impressed on the universe its large-scale structure (Ostriker and Cowie, 1981; Ikeuchi, 1981).

As one can see, future topics of interest are not missing! Much has still to be done to exhaust all the information collected during these first 1001 nights of observing SN 1987 A. These observations will be continued at La Silla, especially in the infrared and sub-millimetre ranges, where more than 80% of the energy is now concentrated. We will also witness the birth of the remnant, watching for any kind of surprise. New telescopes and new detectors will soon be in operation, and new exciting results will certainly be obtained.

References

Arnett, W.D., Bahcall, J.N., Kirshner, R.P., and Woosley, S.E., 1989: *Ann. Rev. Astron. and Astrophys.* **27,** 1.
Balick, B., 1987: *A.J.,* **94,** 671.
Balick, B. and Preston, H.L., 1987, *A.J.,* **94,** 1641.
Bartel, 1990: Proceedings of Santa Cruz Workshop, S. Woosley ed.
Branch, 1977: *Mon. Not. R.A.S.,* **179,** 401.
Chevalier, R.A., 1987: in *Proc. ESO Workshop on the SN 1987 A,* ed. I.J. Danziger (Munich: ESO Garching), p. 481.
Clayton, D.D., 1982: Q.J. Roy. Astron. Soc., **23,** 174.
Danziger, I.J., Gouiffes, C., Bouchet, P., Lucy, L.B., 1989: I.A.U. Circ. 4746.
Danziger, I.J., Lucy, L.B., Bouchet, P., Gouiffes, C., 1990: *Proceedings of Santa* Cruz Workshop, S. Woosley ed.
Dickel, J.R. and Jones, E.M., 1985: *Ap. J.,* **288,** 707.
Fransson, C., Cassatella, A., Gilmozzi, R., Kirshner, R.P., Panagia, N., Sonneborn, G. and Wamsteker, W., 1989: *Ap. J.,* **336,** 429.
Gerola, H., Seiden, P.E., 1978: *Astrophys. J.,* **223,** 129.
Herbst, W., 1977: in "Supernovae", Proc. of a special IAU session on supernovae, held on September 1976, at Grenoble, France; ed. D.N. Schramm; Astrophysics and Space Science Library, Vol. 66, D. Reidel Publishing Company.
Hillebrandt and Höflich, 1990: Preprint Max-Planck-Institut für Physik und Astrophysik, MPA 458, May 1989; to appear in Progress in Physics.
Ikeuchi, S., 1981: In "Fundamental Problems in the Theory of Stellar Evolution", IAU Symposium 93, p. 103; D. Sugimoto, D.Q. Lamb and D.N. Schramm eds.; D. Reidel Publishing Company.
Klein, 1990: Proceedings of Santa Cruz Workshop, S. Woosley ed.
Lee, Pappanasstassiou and Wasserburg, 1976: *Bull. Am. Astron. Soc.,* **8,** 457.
Lucy, L.B., 1988: in "Supernova 1987 A in the LMC"; Proceedings of the 4th George Mason Astrophysics Workshop, eds., M. Kafatos and A. Michalitsianos.
Lucy, L.B., Danziger, I.J., Gouiffes, C., and Bouchet, P., 1989: in IAU Colloquium 120, "Structure and Dynamics of Interstellar Medium"; Eds. G. Tenorio-Tagle, M. Moles and J. Melnick (Springer-Verlag).
Lucy, L.B., Danziger, I.J., Gouiffes, C., and Bouchet, P., 1990: Proceedings of Santa Cruz Workshop, S. Woosley ed.
Mueller, M.W., Arnett, W.D., 1976: *Astrophys. J.,* **210,** 670.
Öpik, 1953: *The Irish Astron. Journal,* **2,** 219.
Ostriker, J.P., Cowie, L.L., 1981: *Astrophys. J.* (Lett.), **243,** L127.
Suntzeff and Bouchet, 1990: *Astron. J.,* to appear in February 1990.
Wampler, E.J. and Richichi, A., 1989: *Astr. Ap.,* **217,** L21.
Wamsteker, W., Gilmozzi, R., Cassatella, A., and Panagia, N., 1987: *IAU Cir.,* No. 4410.
Weaver, T.A., Woosley, S.E., 1980: *in* "Supernova Spectra", AIP Conf. proc. 63, p. 15; ed. R. Meyerott, New York, AIP.

The Bolometric Light Curve of SN 1987 A

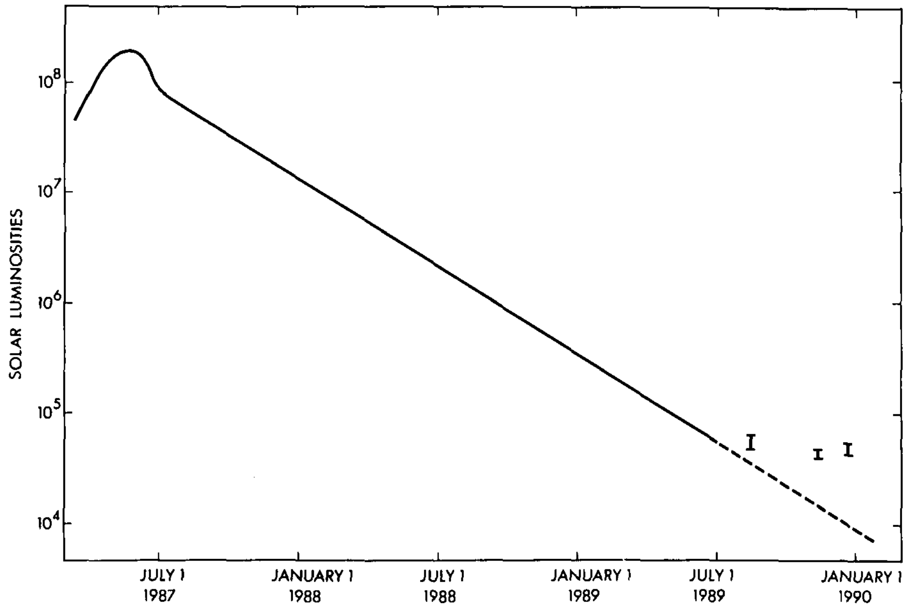
Continuing IR photometry in the J, H, K, L, M, N1, N2, N3, Q bands at ESO – La Silla combined with UBVRI photometry reported from CTIO (IAUC 4881, 4910) shows that the bolometric light curve on 10 November 1989 (day 991) lies 1×10^{38} ergs s^{-1} above a linear extrapolation from earlier epochs (Suntzeff and Bouchet, *A.J.* 1989, in press). This levelling off was already apparent for the previously observed day 14 August 1989 (day 903) though at a lower level of significance and is confirmed by observations in less than ideal conditions on 20 December 1989 (day 1030) when black body fitting gives T = 160 K and log L = 38.30 ± 0.05. Because more than 80 per cent of the flux is now emitted redward of the M band, the levelling off is almost completely due to the near constancy of the flux integrated over the M, N, Q bands for days 903, 991 and 1030. This implies that a hitherto undetected energy source is now contributing significantly to the total energy output. If it were due to ^{57}Co, the original amount would have to be 20–25 times the anticipated 0.0017 solar masses (Woosley and Pinto, Workshop on Gamma-ray Spectroscopy, 1988), but this is contradicted by the observed [Co II] 10.52 μ line strength on day 526 (Danziger et al., Proceedings of Santa Cruz Workshop, July 1989). A thermal echo from external dust seems unlikely since it would coincidentally need to have a colour temperature (150–180 K) similar to that of the SN's emission. Moreover, the corresponding scattering echo (cf. IAUC 4746) is not evident in the smooth UBVR light curves (IAUC 4881, 4910). Nevertheless, CCD frames should be inspected for new echoes within 5 arcsec of the SN.

Uncertainties in luminosities derived by fitting black body curves to the far-IR data have been checked using emission curves for isothermal dust clouds of astronomical silicate. With a dust mass 0.05 solar masses, inefficient dust emission at $\lambda > 30\ \mu$ lowers the luminosity by only 0.1 dex.

Pulsar emission, absorbed and reradiated by dust in the ejecta (IAUC 4746), seems the most likely explanation of our observations. Other spectroscopic signatures of such input should be sought.

Subsequent IR observations in January and February 1990 substantiate the flattening of the light curve.

P. Bouchet, I.J. Danziger, L.B. Lucy (ESO)



The bolometric light curve of Supernova 1987A ▶

A Photometric Study of the Bright Cloud B in Sagittarius

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1. Introduction

The study of the intrinsic properties of variable stars provides important information about stellar populations in the galactic bulge. The period of a variable star has the advantage of being independent of the distance, whereas the general distribution of stars in a colour-magnitude diagram is strongly influenced by the interstellar absorption.

It is this particular property of the variable stars which has led to numerous photographic studies since 1951 in the direction of the galactic centre, in order to detect such stars and to measure the distance between the Sun and the centre of our Galaxy. In the course of this work various objects have been studied, such as the areas around the globular cluster NGC 6522 and the sources Sgr I and Sgr II in which many variables of the RR Lyrae type have been detected (blue variables, giants of spectral type A-F with $0.2 < P < 0.5$ and A (amplitude) < 0.8, distance indicators used in particular for the determination of the extragalactic distance scale).

But the study of red variable stars in these regions is even more important and fruitful because we know that M-type giants are a major component of the stellar population in the central regions of galaxies of types E, S0 and Sb (our galaxy is of type Sb or more exactly SAB (rs) bc according to de Vaucouleur's classification scheme).

In 1958, Nassau and Blanco (1958) were the first to prove, with the help of objective prism plates, that there exists a large number of M giants in the field of the globular cluster NGC 6522. This work was later followed and enriched by V and I plates (Klube, 1966), on which the detection of M giants was facilitated by means of the large values of the colour index (V-I).

On the other hand, the accumulation of photographic data in J, H, K, L of the Johnson system for long-period variables (LPVs) detected in the Magellanic Clouds and in the solar neighbourhood (Wood and Bessel, 1983), as well as the refinement of the pulsation theory for Mira Ceti type variables (Fox and Wood, 1982) have permitted the deduction of certain fundamental physical properties of the LPVs. It was in this way that Wood and Bessel, in 1983, were able to show that the LPVs near the galactic centre differ considerably from those in the Magellanic Clouds and in the Local Group: While the J-K colours in these three regions are practically the same for $P < 250$ days, the LPVs near the centre of the Galaxy are particularly red when compared to other variable stars of the Mira Ceti type and they are all stars of spectral type M.

In 1965, working in particular in the red and near infrared photographical regions of the spectra ($\lambda_{eff} \sim 640$ and 830 nm), I detected 421 red variable stars (Terzan 1965, 1966, in the field of one square degree centred at the star 45 Oph ($\alpha = 17^h\ 24^m.1$; $\delta = -29°\ 49'$).

In the same year, Arp (1965) studied the particularly important question about the contamination of the population in the region of NGC 6522 by the projection in the same field of the images of the stars situated between the cluster and the Sun. He concluded that about 90 % of the stars which have a colour (B-V) = 1.0 are indeed stars at large distance which belong to the population in the central region of the Galaxy and resemble a stellar cluster and where the difference in magnitude from the centre to the exterior (in the direction from the galactic centre towards the Sun) is only 0.3 mag.

In 1966, Clube demonstrated that the stars which have V > 15.5 and B-V > 1.6 are mainly situated in the galactic bulge.

Then, in 1976, Lloyd Evans (1976) after a comparison of V and I plates taken in three selected fields towards the galactic centre (NGC 6522, Sgr I, Sgr II), confirmed the predominance of red stars in the galactic bulge. He detected, in particular, 121 red variable stars of the Mira Ceti type having periods significantly longer than those located in globular clusters.

This short historical overview in which only a few important steps in the study of the content of the galactic bulge have been mentioned, shows how interesting it is to continue the photometric study of the central region of the Galaxy, in order to enrich our knowledge about the content of the galactic bulge and to search for those objects (variable stars, open and globular galactic stellar clusters, diffuse objects, galaxies, proper motion stars, planetary nebulae, etc.) which populate the bright cloud B in Sagittarius or are seen in this central direction of the Galaxy.

2. Plan and Method of Working

The plan and method of working, the chronology and place of the observations, the method of dividing into 4 parts a large field of 10° × 10° centred on the star 45 Oph, the reason for the creation and study in the first place of a central field O and the description of the proposed stages in the advancement of the programme of work have been described previously (Terzan, 1977; Terzan et al., 1982; Terzan and Turati, 1985; Terzan and Ounnas, 1988).

When the analysis of our U, B, V and R plates, covering a field of 10° × 10°, centred on star 45 Oph, is finished, we will undertake an individual study of all these new variable stars, in order to determine for the majority of them the period, the amplitude and the type as well as a study of the spatial distribution, not just in square degree but also in the different types of variability.

The last phase of this programme will necessitate a great deal of work in photoelectric or photographic photometry in one or several of the four chosen spectral domains U, B, V and/or R as a function of their luminosity.

Thus we hope to reach the final goal of our research which is essentially the analysis (detection and study) of the objects populating the galactic bulge and offering a very rich subject matter to contemporary astrophysics and enabling us to advance our knowledge of the central region of the Galaxy.

3. Variable Stars

3.1 OBSERVATIONS

All of the photographic plates studied for the present work originate from two series of observations made:

- in June-July 1968, by Terzan at the 48″ Schmidt telescope (f/2.44, 67″.1 mm^{-1}) of Mount Palomar Observatory, on 10″ × 10″ plates;
- since 1976, by technical collaboration of Schuster at the ESO 1-m Schmidt telescope (f/3, 67″.5 mm^{-1}) of ESO/Chile, on 12″ × 12″ plates.

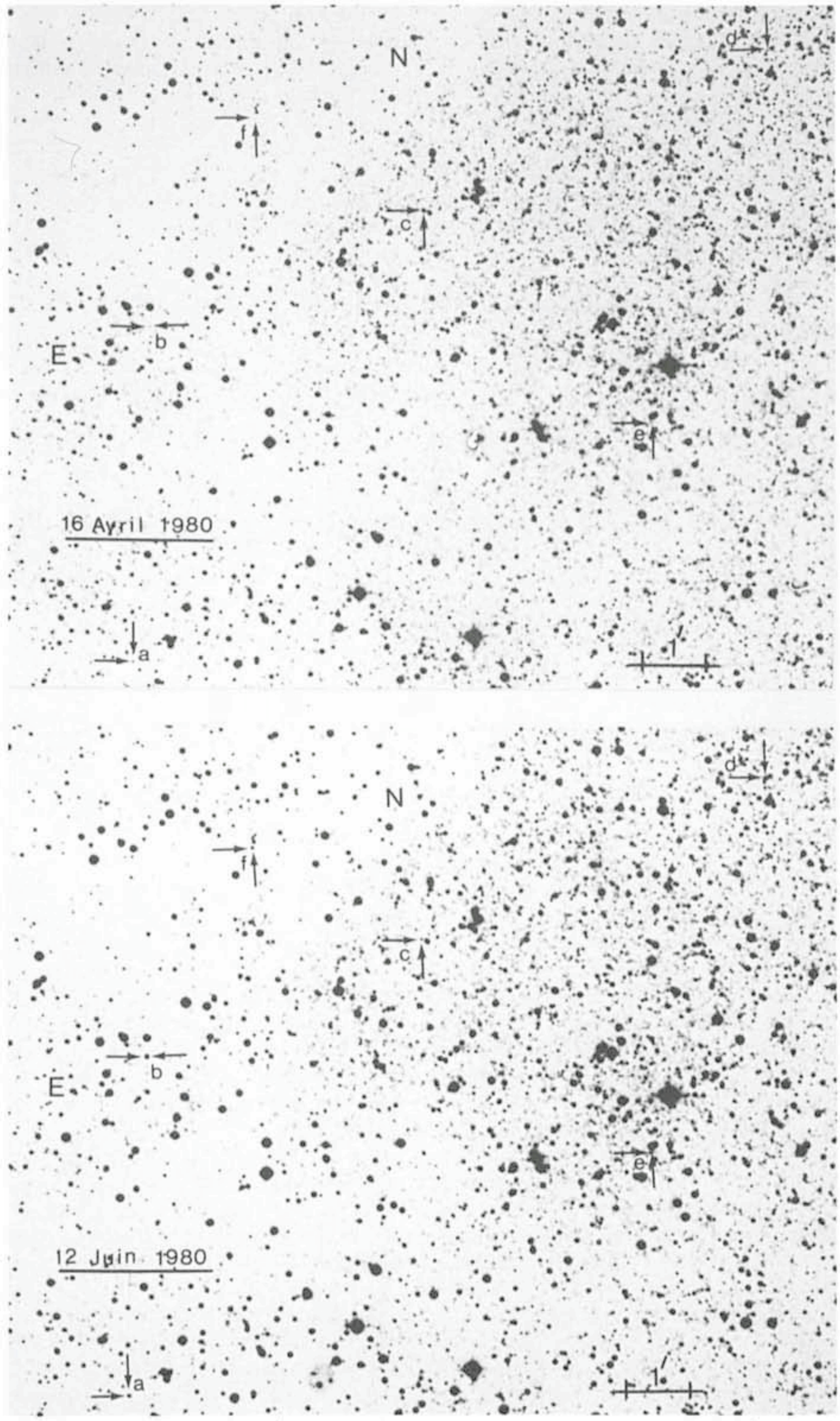


Figure 1: *New variable stars detected north of the globular cluster Terzan 1: $\alpha = 17^h\,32^m\,35^s$, $\delta = -30°\,26'\,18''$.*
Top: R plate ($\lambda_{eff} \simeq 6400$ Å) No. 3716, taken on April 16, 1980 with the ESO Schmidt telescope on La Silla.
Bottom: R plate ($\lambda_{eff} \simeq 6400$ Å) No. 3757, taken on June 12, 1980 with the ESO Schmidt telescope.

3.1.1 Detection

The blink microscope of the Observatoire de Lyon was used to make comparisons among all the B, V and R plates of the fields A, D and B. Equipped with 5 eyepieces of different magnification, the mechanical, optical and electronic performance of this instrument enables the detection of a difference in brightness of the order of 0.2 mag and the reading, with a precision of ±3 μ of the X; Y coordinates relative to an arbitrary origin.

On the other hand, the provision, on one of the beams which scans the plate, of an optical system comprising two lenses, enables, by making small changes in positioning, the compensation

– for the difference in focal length occurring between the exposure of plates (at the same telescope) on different occasions, or

– for the difference in scale between two plates originating from different telescopes but with comparable scales (67″.1 mm^{-1} for Palomar Schmidt telescope/67″.5 mm^{-1} for ESO Schmidt telescope).

3.1.2 Measurements of the coordinates (α, δ; l, b)

The measurement of the coordinates X and Y of each variable star and their transformation into α and δ (equinox 1950.0) and then into l and b, was done at ESO Garching with the microdensitometer S 3000-Optronics.

The precision of the measurements for α and δ is ± 0″.3.

3.2 RESULTS

3.2.1 Variable stars of types L and/or M

In chronological order of the reductions, we have detected:

– Field O: 621 red variable stars (Terzan et al., 1982) (Fig. 1)

– Fields A + D: 1592 red variable stars (Terzan and Ounnas, 1988)

– Field B: 1238 red variable stars (Terzan, 1990)

In all 3451 stars.

The histogram (Fig. 2) shows N, that is the number of stars for which it has been possible to determine the "observed amplitude", in amplitude steps of δm = 0.5 magnitude. It shows that

(1) of a total of 1862 variable stars, 503 have an amplitude between 2.1 and 3.0 magnitudes. This is only a preliminary result, because of the 3451 new variable stars discovered in fields O + A + B + D, we have only been able to define A = R [max] – R [min] for 1852 of them. The others have a R [min] which is uncertain: approximately equal to or fainter than 18 mag.

The grouping of these 493 variable stars in an amplitude interval between 2.1 and 3.0 mag. leads us to formulate the hypothesis that in the direction of the galactic centre the variable stars of L and/or M type are probably more numerous than in other regions of our Galaxy.

The confirmation or the disproval of this hypothesis is only possible after the termination of the studies of the variables in the remaining field C and the construction of the light curves and the determination of the type of variability for all of the variables which have been discovered.

(2) The number of variable stars decreases very rapidly towards large amplitudes.

3.2.2 Cepheids and/or RR Lyr type variable stars

The detection and the study of new, short-period variable stars of RR Lyr and Cepheid type is the subject of another research programme which will follow and complement the current work.

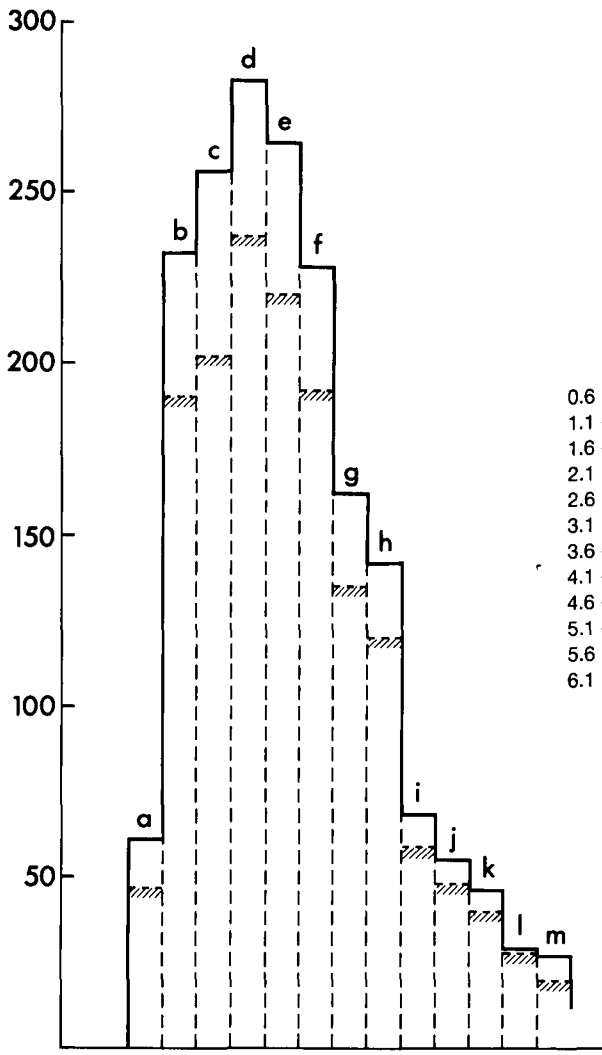
We already have many U and B plates covering the fields O, A, B, C, and D. An UBV photometric sequence has already been established (Terzan and Bernard, 1981) for the future measurements. For the time being, we try to enlarge our plate collection, by repeating the B observations, 2 or 3 times each night, in order to establish the light curves (for the RR Lyr variables) by means of a large number of measurements.

4. Planetary Nebulae

In view of their spatial distribution – mainly in the galactic plane with a strong concentration towards the glactic centre – the current study will eventually lead us towards the discoveries of new planetary nebulae. The number of planetary nebulae known in our Galaxy is now 1180, cf. the new catalogue by Acker (1990).

It is estimated that the total number may be of the order of 20,000, but this is only an approximate estimate in view of the uncertain knowledge of the distances, even if R_o, the distance between the Sun and the galactic centre, is quite well known.

What concerns the detection of new planetary nebulae in the direction of the galactic centre, the possibilities are rather small because optical studies in this direction are made very difficult by the strong and very irregular extinction over the entire field. Contrarily, planetary nebulae are strong emitters in the far-infrared spectral region and the IRAS (Infra-Red Astronomical Satellite) measurements can help us to make new identifications. The IRAS Survey in the



FIELD

	A+D+B+O	A+D+O
a < 0.5	61	47
0.6 < b < 1.0	232	190
1.1 < c < 1.5	256	202
1.6 < d < 2.0	282	237
2.1 < e < 2.5	265	220
2.6 < f < 3.0	228	192
3.1 < g < 3.5	162	135
3.6 < h < 4.0	141	120
4.1 < i < 4.5	68	59
4.6 < j < 5.0	55	48
5.1 < k < 5.5	46	40
5.6 < l < 6.0	29	28
6.1 < m	27	20
	1852	

Figure 2.

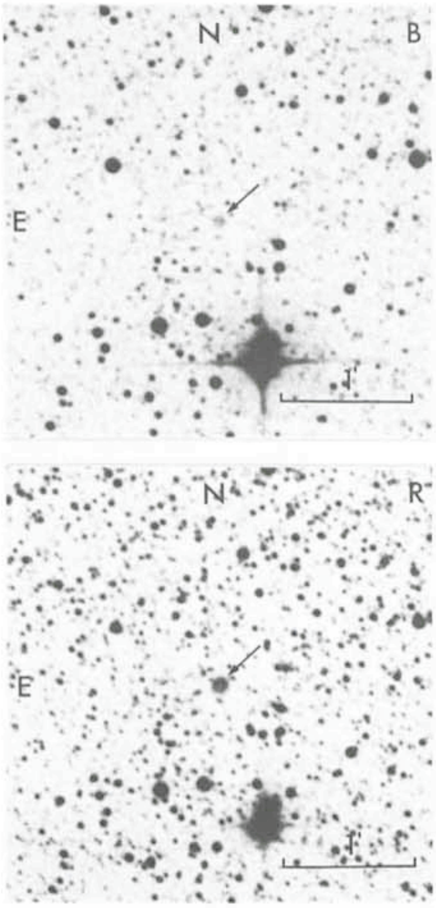


Figure 3: *Identification charts in B and R of a new possible planetary nebula: $\alpha = 17^h\,39^m\,24^s$, $\delta = -25^\circ\,44'\,05''.5$; $l = 2.3$, $b = 2.3$. Position on ESO/R (No. 520): X = 102 mm; y = 110 mm.*

12–1000 μm region overcomes the difficulty of the strong extinction in the visible region. But the limited spatial resolution of the IRAS measurements (3–5 arcminutes) is an inconvenient obstacle for the identification of individual objects and it gives no information about their morphology.

Despite all the advantages and disadvantages of the choice of observation (photographical or IR), the continued study of our UBVR plates of the central region of our Galaxy has enabled us to discover 10 new PN candidates (Terzan and Ounnas, 1988) in fields A and D. After the photometric study of field B, this list has been enlarged by 16 other candidates.

Figure 3 shows photographic reproductions in B and R of one of our most recent PN candidates.

This demonstrates that good plates always have surprises in stock for us and that "The ESO/SERC Survey of the Southern Sky is by far not exhausted of its riches!" (Saurer and Weinberger, 1987).

5. The Discovery of Galaxies in a Direction Near the Galactic Centre

In 1978, I detected three diffuse objects (Terzan et al., 1978a, b) 2 degrees west of the galactic centre, and only 5 degrees from the galactic plane. These detections were made on ESO Schmidt telescope plates and were subsequently confirmed by photographic observations with the ESO 3.6-m telescope.

In 1980, when 24 other diffuse objects in the same region were announced (Terzan and Ju, 1980), I put forward the hypothesis that most of them could be galaxies, seen through a "second transparent window", a region with less interstellar obscuration. Unfortunately, the observed images did not allow any morphological study.

The possible confirmation of the extragalactic nature of these objects necessitated the establishment of a new

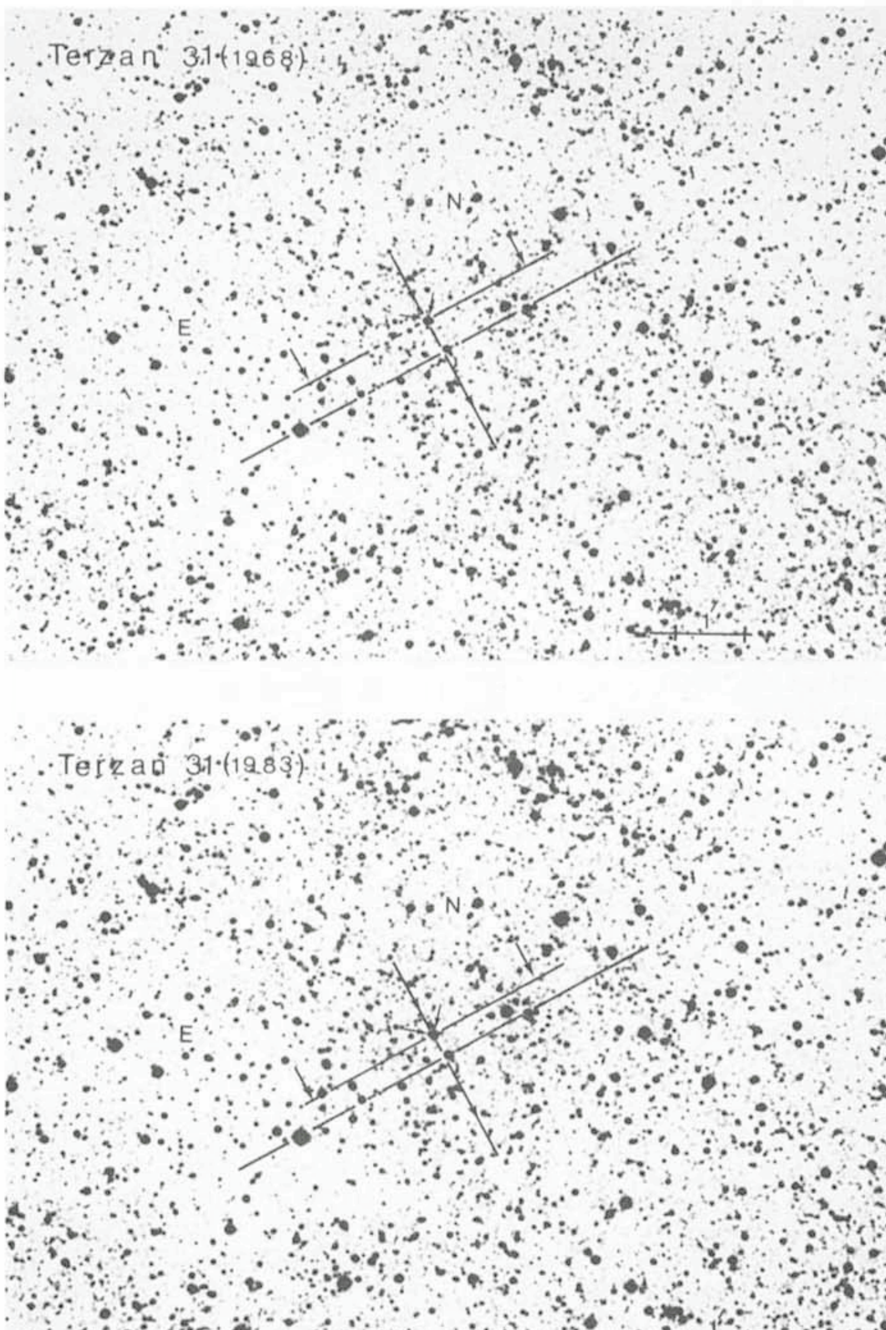


Figure 4: *High proper-motion star Terzan 31: $\alpha = 17^h\,28^m\,49^s.9$, $\delta = -29^\circ\,48'\,58''.4$; $m_{pg} = 16.5$, $m_r = 15.0$, $\mu = 0''.585$, $\theta = 215^\circ$.*
Top: R plate ($\lambda_{eff} = 6400$ Å) No. PS 3753, taken on June 24, 1968 with the Schmidt telescope of the Mount Palomar Observatory.
Bottom: R plate ($\lambda_{eff} = 6400$ Å) No. 5205, taken on August 1, 1983 with the ESO Schmidt telescope.

observational programme and the taking of plates with a large telescope.

In 1981, Johnston et al. (1981), during their search for an optical counterpart of the extended X-ray source detected with the HEAO 1 Scanning Modulation Collimator near 4 U 1708-23 ($l = 0\overset{\circ}{.}5$; $b = 9\overset{\circ}{.}4$), found an anonymous z = 0.03 cluster of galaxies (CL 1709-233), the Ophiuchus Cluster which falls outside the northern limit of a field. Within a $2\overset{\circ}{.}1 \times 2\overset{\circ}{.}6$ rectangle, centred on their so-called "dominant central galaxy" (17^h 09^m $25\overset{s}{.}6$; $-23°18'35''$, 1950.0), Johnston et al. have found 108 galaxies and they suggest that the steep-spectrum radio source MSH 17-023 is associated with this cluster.

The successive additions to this list of diffuse objects (originally defined as "galaxy?" or "nucleus of galaxy?" (Terzan, 1985; Terzan and Ounnas, 1988; Terzan, 1990) have now confirmed our hypothesis (Terzan, 1985), namely that:
– there is indeed a "second transparent window", very near the galactic centre, near the north-east border of the Bright Cloud B in Sagittarius,
– the extent of the Ophiuchus Cluster is considerably greater than $2\overset{\circ}{.}1 \times 2\overset{\circ}{.}1$,
– the number of objects which populate it is well above 108 (Johnston et al., 1981).

In June 1986, an observing programme of the Ophiuchus Cluster in UBVR with the ESO Schmidt Telescope was carried out with great success.

The reduction and the continued study of the new plates will permit us to count accurately the galaxies which populate this cluster, as well as to determine the morphological types, their distribution in the cluster. Moreover, it will tell us how large the window is and also the size of the cluster.

6. New Stars With Proper Motions $\mu > 0.2$ arcsec/year

In 1980, 42 nearby stars were detected in the direction of the galactic centre (Terzan et al., 1980) by means of their large proper motions, above 0.2 arcsec per year. One of these (No. 31) had already been mentioned in 1964 (Terzan, 1964) as having a large motion (Fig. 4).

In 1988, the measurements and the study of our plates of fields A and D had enabled me to detect a total of 185 other, new stars with proper motions in excess of 0.2 arcsec per year (Terzan et al., 1988).

When the measurements of all plates of fields O, A, B, C and D have been completed, we shall start a photometric study of these stars, in particular a study of the white dwarfs which may be among them.

Name	X-ray source designation	
Terzan 1	XB 1733-30	(Makishima et al., 1980)
Terzan 2	XB 1724-31	(Grindlay, 1978)
Terzan 3	XB 1745-25	Makishima et al., 1980)

A preliminary observing period (Terzan, May 1989, 1-m telescope with the QUANTACON photometer, UBVRI) within this programme resulted in the measurement of 58 stars, each at least twice over 6 nights (r.m.s. = ± 0.02 mag), but not a single white dwarf was identified.

7. Open and Globular Stellar Clusters

7.1 OPEN CLUSTERS

The presence of a "grouping" of some bright stars on a photographic plate within a relatively small area (~ 1′ – 2′) is by no means proof of the existence of an open galactic cluster, especially in the central direction of the Galaxy. This "grouping", which often is the image of a real open cluster, may sometimes only be the result of a simple "projection" effect of star images in a given direction. for this reason, photometric studies are absolutely necessary.

For instance, object No. 20 (Terzan and Ju, 1980), visible on UBV and R plates, seems to be an open galactic cluster. However, before its true nature can be confirmed, it is necessary to establish and discuss the U-B/B-V and V/B-V diagrams following UBV measurements of all the stars supposed to be "members" of this cluster.

7.2 GLOBULAR CLUSTERS

In 1966, a total of 112 globular clusters were known in our Galaxy. In 1972, after extensive photographic observations and careful reduction of the plates obtained in the red and near-infrared photographic wavelength region, resulting in the discovery of 11 new globular clusters (Terzan 1-11), this number had increased to 123. This represents an increase of 10% of the number of objects, which are the oldest known objects, showing up soon after the Big Bang and whose chemical composition is related to that of galaxies in their earliest evolutionary stages and whose ages constitute an important observational parameter for cosmological models. As an important particularity we may mention that the globular clusters Terzan 1, 2 and 5 are "extended X-ray sources", detected with the HEAO 1 Scanning Modulation Collimator.

At present, after the recent discovery of three other galactic globular clusters by Djorgovsky (1987), their total number amounts to 130. To this list must be added another 13 "candidates" (Terzan, 1985, 8 objects; Terzan, 1990, 5 objects), whose detailed morphological study is envisaged in June 1990 at the ESO 1.52-m telescope.

Conclusion

The importance of this kind of research consists not only in the large number of discoveries of many new members of the one or the other group of objects (variable stars, planetary nebulae, open or globular stellar clusters, proper-motion stars, galaxies, etc.). Above all, it should be stressed that the availability of an extensive collection of observational data now enables us to proceed with a detailed study of the objects which populate the galactic bulge. It provides modern astrophysics with a vast material and promises to increase our knowledge about the central region of our Galaxy.

References

Acker, A., 1990, private communication.
Arp, H., 1965, *Ap. J.* **141,** p. 43–72.
Clube, S.V.M., 1966, *Roy. Obs. Greenwich – Cape Bull.* No. **111,** 345.
Djorgovski, S., 1987, *Ap. J.* **317,** L13–L14.
Fox, M.W. and Wood, P.R., 1982, *Ap. J.* **259,** 198.
Grindlay, J.E., 1978, *Ap. J.* Lett. **224,** L107.
Lloyd Evans, R., 1976, *M.N.R.A.S.* **174,** p. 169.
Makishima, K. and al. 1981, *Ap. J.* Lett. **247,** L23.
Nassau, J.J. and Blanco, V.M., 1958, *Ap. J.* **128,** 46–56.
Saurer, W. and Weinberger, R., 1987, *A & A Suppl. Series,* **69,** p. 527–531.
Terzan, A., 1965, *Ann. d'Astrophys.* **28,** No. 6.
Terzan, A., 1966, *J. des Observateurs,* **49,** No. 6.
Terzan, A., 1977, *The Messenger,* **10,** 1.
Terzan, A., Bernard, A. and Ju, K.H., 1978a, C.R. *Acad. Sc. Paris* **287,** Série B, 157.
Terzan, A., Bernard, A. and Ju, K.H., 1978b, C.R. *Acad. Sc. Paris* **287,** Série B, 235.
Terzan, A. and Ju, K.H., 1980, *The Messenger* **20,** 6.
Terzan, A. and Bernard, A., 1981, *A & A, Suppl. Series* **46,** p. 49–56.
Terzan, A., Bijaoui, A., Ju, K.H. and Ounnas, Ch., 1982, *A & A, Suppl. Series,* **49,** 715–743.
Terzan, A., 1985, *The Messenger,* **42,** 4.
Terzan, A. and Turati, Ch., 1985, *Mem. S.A.It.* **56,** No. 1, p. 205–211.
Terzan, A. and Ounnas, Ch. 1988, *A & A, Suppl. Series,* **76,** p. 205–253.
Terzan, A., 1990, in preparation.
Wood, P.R. and Bessel, M.S., 1983, *Ap. J.,* **265,** p. 748–759.

First Evidence of DIB Carriers in the Circumstellar Shell of a Carbon Star

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The origin of the diffuse interstellar bands (DIBs) represents one of the longest standing unsolved problems in astronomy. Although it is well established that they originate in the interstellar medium, no convincing identification of the responsible agent(s) has yet been made. They could be produced by large molecules, e.g. the fashionable polycyclic aromatic hydrocarbons (PAHs), or by atoms adsorbed on interstellar grains. A search for DIB features in stars with circumstellar dust shells (CDSs), carried out twenty years ago, was unsuccessful. It was therefore inferred that the DIB agents are not present in the circumstellar environments of late-type stars. Since then sky surveys have been made in the infrared range and have revealed the existence of numerous red long-period variables, very often enshrouded inside dense CDSs; most of these objects are miras evolving through the asymptotic giant branch (AGB). There is growing evidence that these sources are among the main contributors to the replenishment of the interstellar medium. In these conditions, the absence of DIBs in the spectra of late-type stars appears puzzling. With the new instruments and better detectors available today, it seems worth to readdress observationally this problem.

However, the search for DIB features in late-type star spectra is difficult: one should extract features with probably small equivalent widths against a complex background of blended lines coming from the star. An ideal case one would dream of would be that of a binary system made of an early-type star close to a late-type star either inside its CDS or on the other side of it with respect to us. In such a case, one would be able to probe the circumstellar environment by its absorption effects on the early-type spectrum. The companion should be bright enough in order to allow acquisition of spectra with a good signal to noise ratio. In practice, this means that white dwarfs are excluded; therefore, if the two objects are physically associated, the companion should be less evolved which means that it can be neither a supergiant nor a star earlier than B2. The line of sight to the companion should pass very near the late-type star in order that the extinction is significant, but not too much if one wants to get the spectrum of the companion separately. Practically, with the present instrumentation, it means a distance between 1 and 2–3″ for miras up to ~2 kpc.

It does not seem that a systematic search for such cases has ever been done. It is difficult to estimate their probability of occurrence as it depends on many factors, related to the formation and evolution of binary systems, which are still not well known. However, we can suspect that it is not too small since, serendipitously, one such case was found. In a detailed presentation of observations obtained on CS776 [1], it is shown that this carbon star has a companion of type A3. The companion is physically associated to CS776 and at a distance of slightly less than 2″; it is significantly reddened ($A_B \sim 2$). A kinematic distance of 1.3 kpc can be deduced from 2.6 mm CO observations; the projected separation of the companion and the carbon star is therefore ~2000 AU. From the mapping of interstellar extinction around CS776, it appears that there is no significant intervening material; therefore, the reddening of the companion should be due to the circumstellar material lost by CS 776.

The companion of CS776 was observed in April 1989 at the ESO 1.5-m telescope equipped with its recently improved spectrograph [2]. A slit-width of 1.5″ was used; the detector was an RCA CCD (ESO No. 13) with pixel size 15 μm. The companion spectrum could be registered separately from the one of CS776 thanks to the combination of good seeing conditions (< 1″) and excellent optical quality of the refurbished telescope and instrument. For comparison, a bright unreddened star of spectrum A3 was also observed. A division of the object spectrum by the unreddened star spectrum allows the cancellation of the stellar features and an easy search for features due to agents in the CS776 circumstellar shell. Also, care was taken to observe both objects at same airmass for cancelling effectively

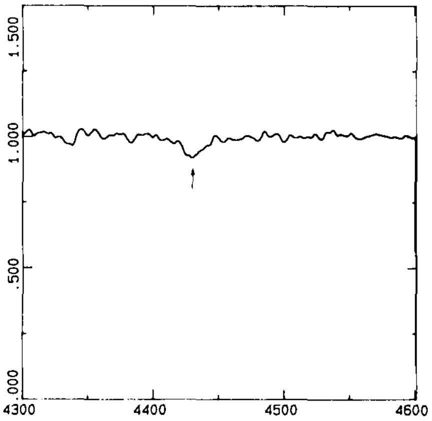

Figure 1: *4300–4600 Å spectrum obtained in April 1989 at the ESO 1.5-m telescope; spectral resolution is ≈ 7 Å (FWHM). The position of the feature at 4430 Å is marked.*

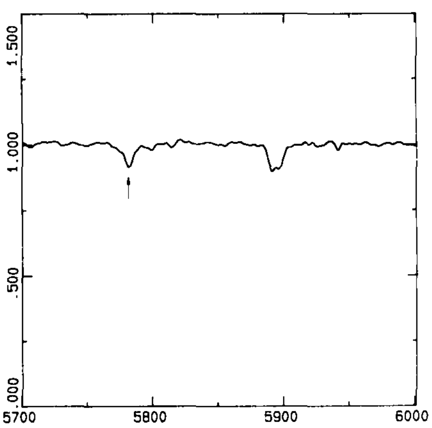

Figure 2: *5700–6000 Å spectrum; the position of the feature at 5780 Å is marked. The sodium doublet at 5890 Å is almost resolved.*

EDITORIAL NOTE

"Discovery of a Low Mass B[e] Supergiant in the SMC" by M. Heydari-Malayeri, ESO (*The Messenger* 58, 37)

Due to a most regrettable incident, a manuscript by Dr. M. Heydari-Malayeri, ESO, La Silla, prepared for the European journal *Astronomy & Astrophysics*, was published in the December 1989 issue of the *Messenger*. The error occurred as a result of a highly unlikely string of individual events during the editorial process. Although publication in our journal automatically excludes publication of the same manuscript in *Astronomy & Astrophysics*, we have been pleased to learn that the editors of *Astronomy & Astrophysics* have decided to make an exception in this particular case and to publish Dr. Heydari-Malayeri's article (with a few, minor changes) in one of the forthcoming issues of that journal. I have expressed my sincere apologies to all involved and immediately taken the steps necessary to avoid such mistakes in the future.

R. M. West, *Messenger* editor

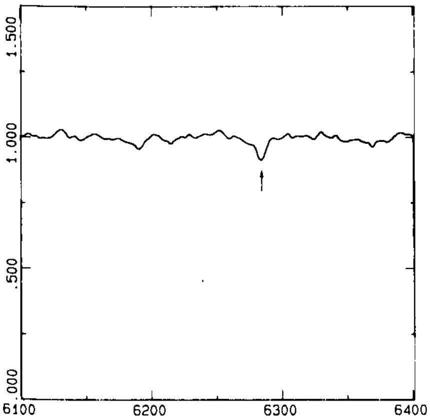

Figure 3: *6100–6400 Å spectrum. The position of the feature at 6284 Å is marked.*

telluric features; this is important for the DIB at 6284 Å which is affected by an O_2 atmospheric band. Grating No. 21 was used in the range 3860–6690 Å. The spectral resolution was ~7 Å (FWHM). The strongest certain DIBs [3] were searched for in the ratioed spectrum. In this spectrum, the DIB at 4430 (Fig. 1), 5780 (Fig. 2) and 6284 Å (Fig. 3) are clearly detected, but not the one at 5797 Å (Fig. 2).

The presence of DIB carriers in a carbon star CDS is of importance. It suggests that at least some of them are carbon-rich and gives support to the hypothesis that some type of PAHs are responsible agents. If PAHs are indeed DIB carriers, it means that the carbon star CDSs are among the sites of formation of PAHs; carbon-rich planetary nebulae were already known as sites of formation of PAHs (see for instance [4]). The ratio of the equivalent widths of 5780 to 5797 Å is ~2 in the interstellar medium [3]; the non-detection of 5797 Å in the CS776 companion spectrum gives support to the principle of dividing DIBs into families [5]. A recent work carried out at ESO [6] shows that the DIB carriers and the 2175 Å feature carriers (most probably small graphite grains) do not share the same origin. The presence of DIB carriers around CS776 suggests that graphite grains or their progenitors are not formed there, and lets little room for the existence of pure-carbon dust in carbon-rich CDSs. It is worth to remind that, around carbon stars, there is unambiguous observational evidence of *only* SiC and MgS grains.

Finally, most studies of DIBs are made at high-spectral resolution (R > 10,000). This is required if one wants to separate the components due to several intervening clouds but limits the sample of observable objects to bright ones and the sample of DIBs to narrow ones. However, the mere detection of DIBs does not necessitate such spectral resolution and the advantages of working at a lower resolution (~1000) are obvious.

References

[1] Le Bertre, T.: 1990, Observational study of CS776, submitted to *Astron. Astrophys.* (ESO preprint No. 691).
[2] Jarvis, B., Hutsemékers, D.: 1989, *The Messenger* **56,** 65.
[3] Herbig, G.H.: 1975, *Astrophys. J.* **196,** 129.
[4] Le Bertre, T.: 1988, *The Messenger* **53,** 55.
[5] Krelowski, J., Walker, G.A.H.: 1987, *Astrophys. J.* **312,** 680.
[6] Benvenuti, P., Porceddu, I.: 1990, *Astron. Astrophys.* **223,** 329.

PHL 1222: an Interacting Quasar Pair?

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The "By-Product" of a Survey

The origin of quasars and Active Galactic Nuclei (AGN) is one of the outstanding problems of modern extragalactic astronomy. Mergers and gravitational interactions between galaxies are probably more frequent at large redshifts, and may lead to the appearance of quasars and other AGN. As a matter of fact, there is now an increasing body of evidence – from observations and computer simulations – that gravitational interactions between galaxies may be somehow responsible for the onset and fueling of the nuclear activity (e.g., Hernquist 1989, and references therein).

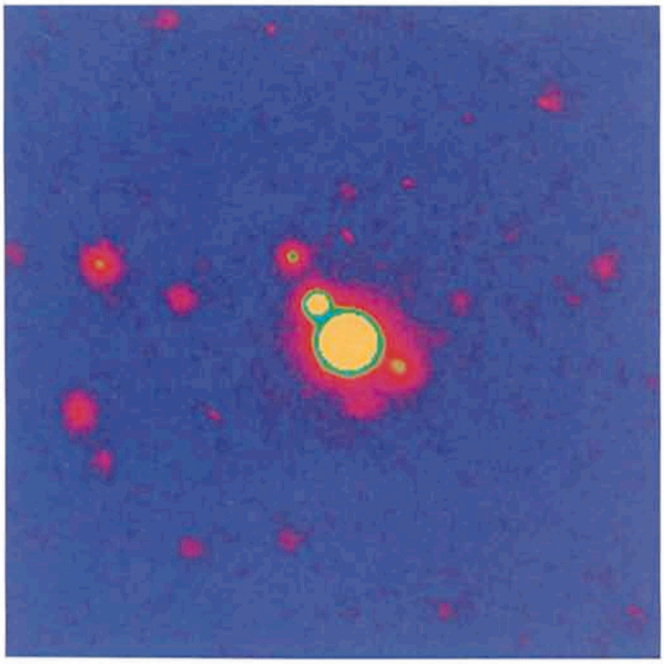
Three close pairs of quasars or AGN at large redshifts have been discovered recently: PKS 1614+051, QSO + AGN, at z = 3.215 (Djorgovski et al. 1985, 1987a), PKS 1145–071, QSO + QSO, at z = 1.345 (Djorgovski et al. 1987b), and QQ 1343+266, QSO + QSO, at z = 2.030 (Crampton and Cowley 1987). In these three systems we may be witnessing the triggering events responsible for the nonthermal activity in both objects, i.e., the birth of pairs of AGN at redshifts where the comoving density of quasars was close to its maximum. Their further study, and discoveries of more such systems, can help us to better understand the processes responsible for the origin and maintenance of nonthermal activity in the cores of galaxies.

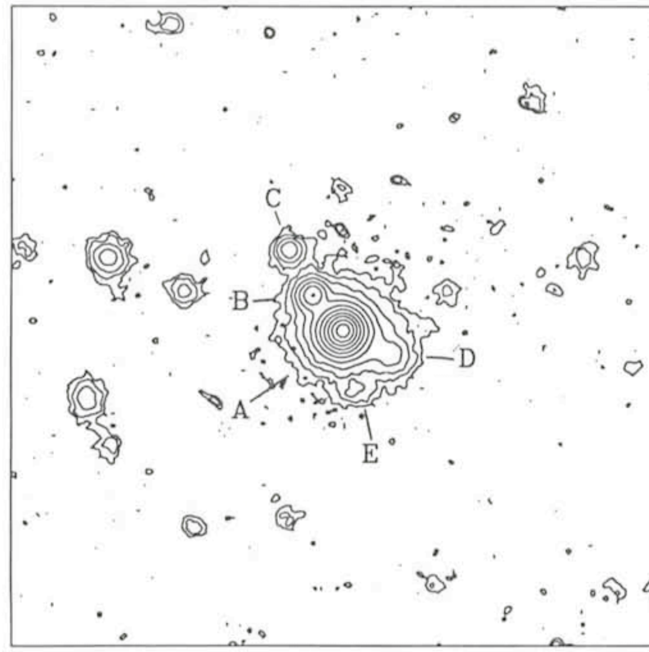
We report here the discovery of a close pair of quasars, possibly the most interesting system of its kind, known as PHL 1222 = UM 144 = QSO 0151+048. It is composed of a close physical pair of QSOs with similar redshifts, $z \simeq 1.91$, and separated by 3.3 arcsec (Meylan et al. 1989, 1990).

The discovery of such pairs of quasars is the by-product of a survey for gravitationally lensed quasars. We are conducting such an optical imaging survey, with a spectroscopic follow-up for the promising cases. A sample of known QSOs has been selected on the basis of apparently large absolute luminosities and high redshifts. So far, this survey has yielded one close pair of possibly interacting quasars, PKS 1145-071 (Djorgovski et al. 1987b), one very probable gravitational lens, UM 425 (Meylan and Djorgovski 1989), several other promising lens candidates, and several cases of foreground or associated galaxies within a few arcsec from the quasars (Djorgovski and Meylan 1989, and Meylan et al. 1990). Our survey has now merged into the ESO Key Programme for Gravitational Lensing (Surdej et al. 1989).

PHL 1222: the Initial Observations

The quasar PHL 1222 = UM 144 = QSO 0151+048 (Burbidge 1968) is one





Figures 1a and 1b: *Figure 1a contains a false-colour image of the PHL 1222 system and Figure 1b displays the corresponding contour map. Both figures come from the same stack of CCD VR frames obtained at La Silla with the 2.2-m telescope, with a total integration time of 4.5 hours. The field shown is 45 × 45 arcsec, with north at the top and east at the left. The components of the PHL 1222 system are indicated with letters on the right image.*

of the objects selected as potential lens candidates on the basis of the two criteria mentioned above. The first piece of evidence of the multiple character of PHL 1222 is found in the multicolour CCD frames obtained with the 40-inch telescope at Las Campanas Observatory (Chile) on UT 1988 October 21. These images show at least one close companion (which we denote as B), with the same colours (within the errors) as the bright QSO itself (denoted as A).

The confirmation of the interesting character of PHL 1222 is provided by observations taken at the ESO La Silla observatory. Spectra of both components A and B were obtained with the ESO Faint Object and Spectrograph Camera (EFOSC) at the ESO 3.6-m telescope, on the nights of UT 1988 December 8, 9, and 10. Some deep imaging frames were obtained with a high resolution CCD camera at the ESO/PMI 2.2-m telescope, on the nights of UT 1988 December 11, 12, and 13. Subsequent images and spectra were obtained at Palomar Observatory using the 200-inch Hale telescope and the 4-Shooter imager/spectrograph, on the nights of UT 1989 September 6 und 7.

False-colour image and contour map of the system are shown in Figures 1a and 1b, respectively. Both come from the same stack of CCD VR frames obtained at La Silla with the 2.2-m telescope. The total integration time amounts to 4.5 hours. The field shown is 45 × 45 arcsec, with north at the top and east at the left. The isophotal levels are spaced logarithmically in factors of 2. The components of the PHL 1222 system are indicated with letters: the companions labelled B, C, D, and E, in decreasing brightness, encircle the bright image of the quasar A. The separation between the quasar image A (V = 17.6 mag) and its brightest companion B (V = 21.25 mag) is 3.3 arcsec. The differences in BVR magnitudes between A and B components are almost constant, $\Delta m \sim 3.55$, but from the colour indices, companion B seems slightly bluer than the quasar A. Object C, at 6.8 arcsec from A, is unresolved and redder than A or B. Objects D and E are both resolved, at about 4 arcsec from A; they are very blue in colour.

PHL 1222: a Gravitational Lens or an Interacting Quasar Pair?

The spectra of the two components A and B (with a total exposure time of 3 hours in each B300 and R300 grism) immediately confirmed that both objects are quasars, with the same emission lines (viz., C IV 1549, C III] 1909, and Mg II 2799) at about the same redshift, $z \simeq 1.91$. Differences in velocity between the two spectra have been obtained from emission line redshifts ($\Delta V = 1380 \pm 240$ km s^{-1}) and from cross-correlation ($\Delta V = 520 \pm 160$ km s^{-1}). These ΔV values are typical of velocity dispersion in clusters of galaxies. The relative intensities of the C IV 1549 and C III] 1909 lines are reversed in the spectra of A and B. While the continuum of the faint quasar B is nearly flat, the continuum of the bright quasar A increases significantly from the blue to the red, so much as to have a flux level twice as high in the red than in the blue (thus the bluer B-V colour index of component B). Additionally, the equivalent widths of the emission lines are much larger for the fainter component B. All these dissimilarities in the shapes of the emission lines and the continuum, as well as the differences in redshift, favour the interpretation of PHL 1222 as being a physical quasar pair rather than a gravitational lens.

Component C of the system (see Figure 1), very red in colour, has been weakly detected in the R300 grism spectra. The very low S/N ratio hampers any clear determination of the nature of this object. It could be a foreground galaxy at $z \sim 0.8$ if we interpret the increase in intensity towards the red as the break at 4000 Å. It may also be a foreground galactic star, possibly an M dwarf. The nature of the remaining companions is still unknown. It is possible that we are seeing a compact group or a cluster core still in the process of formation. Further studies of this system are likely to be highly rewarding.

In spite of a few attempts about ten years ago, PHL 1222 has not been detected in radio. Sramek and Weedman (1980) summarize the flux density limits obtained so far: 20 mJy at 1415 MHz, 18.3 mJy at 2380 MHz, and 2.3 mJy at 4885 MHz. We are unaware of any other radio observations of this system.

PHL 1222: a Tentative Estimate of the Total Mass of the System

Under the assumption that the two QSOs are gravitationally bound, and that there is no other massive object in their vicinity, their projected separation and their velocity difference allow us to place a lower limit to the total mass of the system by using the Virial mass equation. At z = 1.91, with H_0 = 75 km/s/ Mpc and $\Omega_0 = 0$, 3.3 arcsec correspond to 28 kpc, whereas with $\Omega_0 = 1$, 3.3 arcsec correspond to 18 kpc. Considering a minimum separation of about 20 Kpc and a minimum velocity $\Delta V = 500$ km s^{-1}, the (minimum) virial mass amounts to about $M_A + M_B \simeq 1.7 \times 10^{11}$ $M_\odot$, a reasonable value for normal galaxies. Allowance for projection effects would suggest a true value of the total mass of the system several times larger than that.

PHL 1222: a Possible Interaction Event

Recent numerical simulations show that gas distributed throughout a galaxy responds strongly to the tidal field of a close companion. In some cases, dynamical instability drives a large fraction of the gas into the inner regions of the galaxy (Hernquist 1989). A strong burst of star formation may follow and subsequent evolution may lead to the formation of a black hole. Continued accretion of gas by the black hole may provide enough power to explain quasars and nuclear activity. From an observational point of view, the "interaction model" seems also to be the dominating paradigm for explaining the origin of nuclear activity in galaxies (cf. Fricke and Kollatschny 1989 for a recent review and further references).

Most interestingly, PHL 1222 was already known to have an absorption system with $z_{abs} > z_{em}$, which almost coincides with the redshift of the fainter component B. This absorption may be a signature of the ambient gas in a probably interacting system. The coincidence between the binary character of PHL 1222 and its $z_{abs} > z_{em}$ absorption system raises an important question: do the other quasars showing $z_{abs} \simeq z_{em}$ also have close neighbours? For example, there is substantial associated Mg II 2799 absorption in component B of the PKS 1145-071 system (Djorgovski et al., in preparation).

Many quasars with $z_{abs} \simeq z_{em}$ have been intensively studied spectroscopically, but not by deep and/or high-resolution imaging (Foltz et al. 1988). It is possible that more interacting systems can be found by imaging quasars with $z_{abs} \simeq z_{em}$. We have already obtained 4 nights at the 3.5-m NTT telescope, which will hopefuly begin to answer this question.

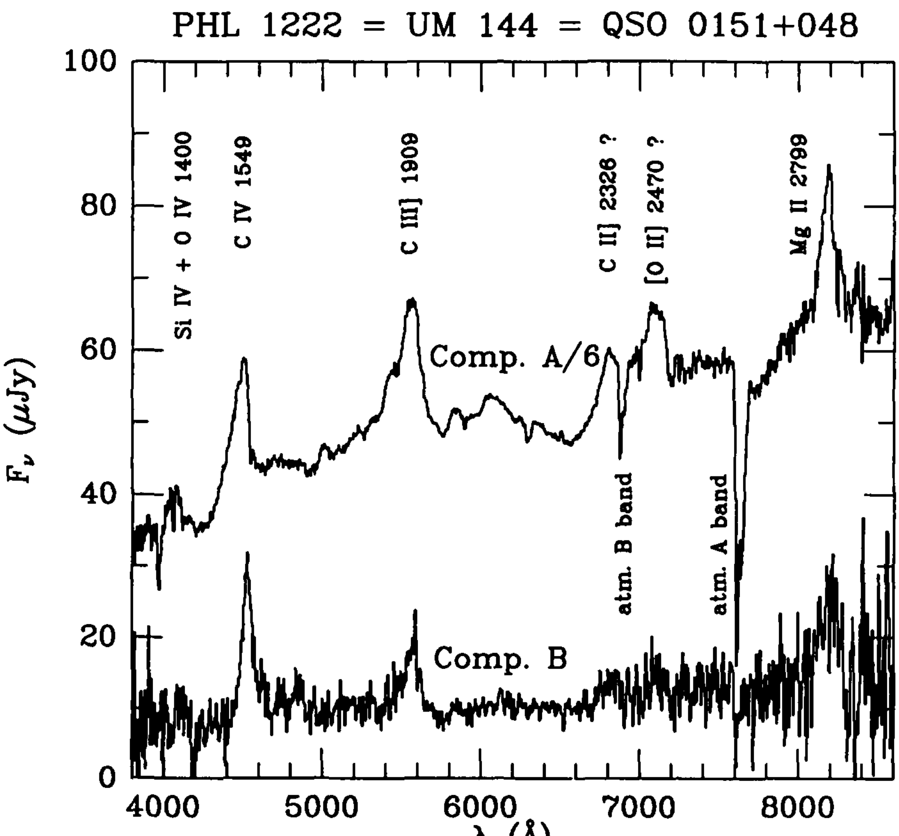


Figure 2: *CCD spectra of components A and B, obtained at ESO, indicating that both objects are quasars. The spectrum of the brighter component A is scaled down by a factor of 6 for easier comparison. The two spectra show some dissimilarities in redshifts, in the shapes of the emission lines (viz., CIV 1549, CIII] 1909, and Mg II 2799) and in the continuum, which favour the interpretation of PHL 1222 as being a physical pair of quasars rather than a gravitational lens.*

References

Burbidge, E.M. 1968, *Astrophys. J.* (Letters), **154,** L109.
Crampton, D., and Cowley, A.P. 1987, *B.A.A.S.*, **19,** 700.
Djorgovski, S., Spinrad, H., McCarthy, P., and Strauss, M.A. 1985, *Astrophys. J.* (Letters), **299,** L1.
Djorgovski, S., Strauss, M.A., Perley, R.A., Spinrad, H., and McCarthy, P. 1987a, *Astron. J.*, **93,** 1318.
Djorgovski, S., Perley, R., Meylan, G., and McCarthy, P. 1987b, *Astrophys. J.*, **321,** L17.
Djorgovski, S., and Meylan, G. 1989, in Moran, J. et al. (eds.), *Gravitational Lenses, Lecture Notes in Physics,* bf 330, p. 173, Berlin: Springer.
Foltz, C.B., Chaffee, F.H., Weymann, R.J., and Anderson, S.F. 1988, in Blades, J.C., et al. (eds.), *QSO Absorption Lines;* STScI Series No. 2, p. 53, Cambridge: Cambridge University Press.
Fricke, K.J., and Kollatschny, W. 1989, in Osterbrock, D., and Miller, J. (eds.), *Active Galactic Nuclei,* IAU Symp. No. 134, p. 425, Dordrecht: Kluwer.
Hernquist, L. 1989, *Nature,* **340,** 687.
Meylan, G., and Djorgovski, S., 1989, *Astrophys. J.* (Letters), **338,** L1.
Meylan, G., Djorgovski, S., and Shaver, P. 1989, *B.A.A.S.*, **21,** 1132.
Meylan, G., Djorgovski, S., Weir, W.N., and Shaver, P. 1990, in Fort, B. and Soucail, G. (eds.), *Gravitational Lenses,* in press.
Sramek, R.A., and Weedman, D.W. 1980, *Astrophys. J.*, **238,** 435.
Surdej, J., et al. 1989, *The Messenger,* **55,** 8.

ADDENDUM

Narrow Band Imaging of M87 with the NTT by B. JARVIS, ESO
(*The Messenger* **58,** 10)

The first reported observation of the H_α + [N II] features in M87 was by Arp (1967) who observed the filamentary feature SE of the nucleus. This was followed by Walker (1968) who discovered a "fan-shaped emission jet" in the light of [O II] Å 3726-29. Ford and Butcher (1979) published ISIT video camera images showing that the H_α + (N II] structure extended to the NE and into the core, van den Bergh (1987) has possibly obtained the deepest images of the filamentary structure in M87 using a CCD but of lower resolution than those obtained in this article.

References

Arp, H.C., 1967, *Ap. J. Lett.***1,** 1.
Ford, H.C., Butcher, H., 1979, *Ap. J. Suppl.*, **41,** 147.
van den Bergh, 1987, IAU Symposium No. 117, 217.
Walker, M.F., 1968, *Ap. J. Lett.*, **2,** 65.

Twenty-three Missions at ESO-La Silla

Research Based on Discoveries and Rediscoveries of About 1400 Planets with the GPO

H. DEBEHOGNE, Observatoire Royal de Belgique

Which Interest?

The science of minor planets is modern research. It influences both astrometry and celestial mechanics, and also related sciences, such as mathematics, physics, astronautics.

Let us recall some important results:

1. Determination of the Astronomical Unit (A. U.), the base of all distances in astronomy;
2. Computation of planetary masses, particularly of those of Venus and Mercury which have no natural satellites;
3. Improvement of our knowledge about the Earth's orbit and rotation;
4. Calculation of systematical errors in stellar positions;
5. The advance of the Icarus perihelion, five times greater than the one of Mercury, supports the Theory of General Relativity;
6. Several problems within celestial mechanics and astronautics benefit from our knowledge about minor planets.

The experience of the minor planets' specialists leads to:

1. Compilation of sky maps and catalogues;
2. Identification of radio sources, quasars, pulsars with optical objects and location of variables, binaries;
3. Determination of the *Einstein effect* during a total solar eclipse, e.g. by means of the simulation method (Debehogne, 1977);
4. Study of the dynamical, physical and chemical properties of space astronomy experiments;
5. Control of artificial satellite network;
6. Research on natural satellites, transplutonian objects, and planetary systems;
7. Determination of stellar proper motions and parallaxes.

Still young after two centuries, this kind of research is a test for astronomical photography, is noticed by the public in connection with the Earth grazers or with targets for interplanetary rockets and takes part in the study of the ring systems whose creation and evolution may explain the origin and evolution of the solar system.

Some peculiar interests are: the discovery of a second ring of asteroids beyond Neptune, the computation of orbits, the families, the poles of rotation, their size, the chemical constitution, their number (4225 minor planets have been numbered by October 1989) . . .

Preparation of the Missions

The choice of plate centres comes from the ITA (Institute of Theoretical Astronomy, Leningrad) diskette, from Ephemeridi Malikh Planet and from the Minor Planet Center (MPC) diskette. For three years now we are computing at Uccle graphs at whatever scale, date, number of positions (T. Pauwels' programmes).

Methods of Observations

Three exposures (1 to 21 minutes × 3) are made with an off-set along δ between each of them. Sometimes, we have two or more fields on the same plate using the Trépied-Metcalf method. Three images permit: safer and easier asteroid identification and discovery; studies of the accuracy of the stellar positions and proper motions; identifications of nearby asteroids; improvement of the possibilities to compute a preliminary orbit.

Measurements and Reductions

We measure and reduce by means of the OPTRONICS at ESO-Garching with West's programmes, or on the ASCORECORD (Valongo-Univ. Fed. Rio de Janeiro or Brussels).

See *Acta Astronomica* (Debehogne, 1986) for the description of the problem in algebra and modern language. Bijections, between sky and plate, are determined by means of sub-sets (reference stars) and with determination of the normal equations by matrix multiplication. We use the Catalogue SAO given on magtape by the "Centre de Données Stellaires à Strasbourg".

Results

Thousands of positions have permitted improvements of orbits or the determination of new ones; 1400 discoveries or rediscoveries have been obtained until October 10, 1989. The 3 discoveries in 1976 became 274 in September 1989 (following the asteroids present on the MPC diskette of 1986). As special observations, let us recall:

1. V 348 Sgr observed in 1979 with a magnitude variation from 12.0 to 17.0 in four days;
2. The Halley Comet, with R. West, the first and only observations 5 days after the perihelion passage, supporting the approach by Giotto;
3. The Earth grazer (distance to the Earth = 900.000 km) which could be a satellite 70.000 km high, but not known by the Satellite Service of the Institute of Space Aeronomy of Brussels.

Users and Orbits

We try to serve all computers of orbits: Minor Planet Center (MPC), Institute of Theoretical Astronomy of Leningrad (ITA) and ourselves. We do not agree with observers who limit their work to two nights, when it is possible to have more. How to compute orbits if each observer limits his observations at two nights for a given asteroid? He has, then, more time to obtain very many discoveries, confirmed by those observers who observe more than two nights and, thus, who make fewer discoveries!

In special and rare cases, I agree that the discovery is given to both observers: first the observer whose observations give an orbit and, secondly, the one who has the first night (see below). On the *Minor Planet Circulars,* many discoveries, with 75% and more observations noted 809 (ESO La Silla-Observatory), are given to another observatory.

More than 1000 orbits were calculated at Uccle by us, using the Gauss-Encke method with amelioration owing to the variations computation (Stracke, 1929).

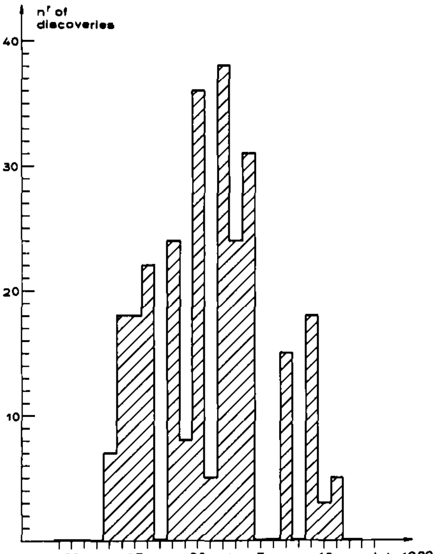


Figure 1: *Discoveries in September–October 1989. To lose a night in the central part of the mission is a catastrophe. Discovery is taken in the sense that the orbital elements are not on the MPC 1986 diskette.*

Connections between CCD and GPO at La Silla

During the night of October 1, 1989, O.H. Hofmann and H. Rabhan found a fast-moving asteroid with a CCD from their home institute, mounted on the ESO 1-m telescope. It was recognized later as 4197 1982 TA, a very recently numbered asteroid.

The following nights, till October 12.0 (Moon = 0.88) and perhaps October 13.0 (Moon = 0.95), we observed this asteroid at the GPO (magnitude equal to 15.6).

M. Hoffmann writes about this collaboration: "Visual discoveries of asteroids by chance have become unusual in astronomical research during this century. New observing techniques, however, have led to a new variety of this "method". When CCD images of star fields are displayed in the control rooms of the telescopes, there is a finite probability that unexpected objects also appear on the screens. Unfortunately, a large fraction of this recorded information remains unnoticed and will be erased from the magtapes eventually.

We had an opportunity to combine the ESO 1-m telescope with a CCD-camera system of the DLR for a programme of photometry of near-Earth asteroids. These objects use to move quickly through considerable angles in the sky.

The night of October 30/31, 1989, we suddenly noticed that one of the background stars in a field of (4197) 1982 TA jumped a little westward from frame to frame. From its speed and direction of motion we concluded that it might be a normal main-belt asteroid close to opposition and estimated its position for the next night. It could then be recovered on exposures of the GPO and followed during the next days.

It is obvious that a CCD camera can lead to many similar discoveries when pairs of images are compared during the subsequent image processing."

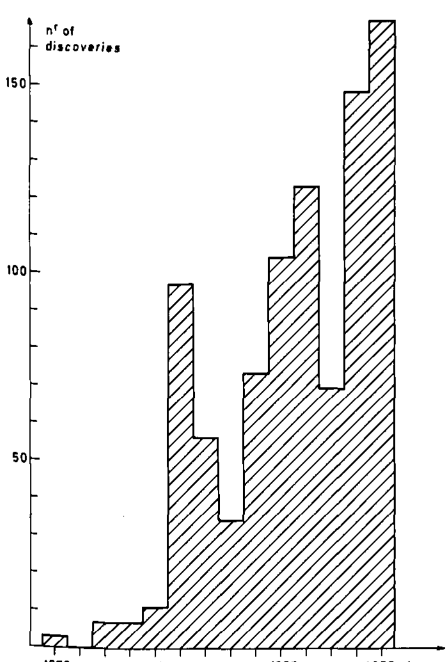


Figure 2: *Discoveries from 1976 to 1989. Discovery is taken in the sense that they are recognized as ours by the Minor Planet Center (MPC). Numbered: 62.*

Institutions Involved

The Observatorio do Valongo, Universidade Federal do Rio de Janeiro (UFRJ), the Observatories of Uppsala, Belgrade, Turin, Rio de Janeiro, the University of Teheran and the Royal Observatory of Belgium (Uccle-Bruxelles) have all taken part in the missions.

Theoretical Developments: New Ideas

Theorem of the minimum. In the reductions (more generally, in the rectangular algebraic systems), the error effect where the error is acting will be minimum at the gravity centre of the reference stars (of the independent terms) only for systems of odd degree (1, 3, 5, 7 . . .), not for even degree (Debehogne, 1972).

The *Einstein effect* must be solved by the simulation method (Debehogne, 1977). This is a work only for astrometrists skillful in asteroids.

In the orbital computations, the effect on the elements of *systematical errors* on the observations is a linear function of the error value and a sinusoidal one of the error direction: for each element we find two directions with an error effect equal to zero for whatever error value (Theorem of the two directions without error effect) (Debehogne, 1988).

The test stars are used to study the *external accuracy* (Debehogne, 1970). Fictitious reference stars and fictitious errors (Debehogne, 1972) are also used.

If it is necessary to use observational sequences from instruments with different focal lengths and to use uncatalogued stars, except on the instrument with the shorter one, then the final accuracy will be the accuracy of the measurements on the plate taken with the larger one, when the subsets of intermediate reference stars are sufficient: the number of stars for each instrument should be equal to 10 times the degree of the bijections used.

Conclusions

Editors, editorial boards and referees ought to support the publication of positions of known and also of new minor planets. The *Minor Planet Circulars* are important, but they are not accepted as publications by the "Money Authorities"?

Each position is the determination of a bijection between two sets of points (sky and plate) by means of two subsets (reference stars). That implicates the resolution of one or two rectangular, algebraic systems of equations (reduced to squared ones, by the matrix or by the least squares method). Such discoveries, such mathematical developments, such theorems, coming directly from the observations and having implications in mathematics, ought to be supported. The lack of publication possibilities is a pity; a new "Journal des Observateurs" would be highly desirable.

Acknowledgements

The photographical service (J. Peres, E. Araya, A. Torrecon, R. Tighe) on La Silla, by plate heating (Kodak IIa-O, 16 × 16 cm), has made it possible for us to obtain a gain of 1.5 magnitudes. ESO supports all missions for H. Debehogne and partly those for a colleague. J. Dumoulin and G. Peeters have participated.

References

Debehogne, H.: 1970, *Astron. Astrophys.*, **8,** 2, 1989.

Debehogne, H.: 1972, *Astron. Astrophys. Suppl.*, **5,** 1985.

Debehogne, H.: 1977, *Bull. Ac. Roy. Belg. Cl. S.*, **2,** 5, 43.

Debehogne, H.: 1986, *Acta Astronomica*, **36,** 301.

Debehogne, H.: 1988, *Astron. Astrophys.*, **204,** 337.

Stracke, G.: 1929, *Bahnbestimmung der Planeten und Kometen.* Springer, Berlin.

STAFF MOVEMENTS

Arrivals

Europe:

BEUZIT, Jean-Luc (F), Coopérant

DICHIRICO, Canio (I), Electrical Engineer

MAZZALI, Paolo (I), Fellow

ZIGMANN, François (F), Coopérant

STANGHELLINI, Stefano (I), Opto-Mechanical Project Engineer

Chile:

CABILLIC, Armelle (F), Administrator

Departures

Europe:

PIERRE, Marguerite (F), Associate

HUIZINGA, Jan (NL), Student

Chile:

GREDEL, R. (D), Fellow (SEST)

Resolving the Fornax Globular Clusters with the NTT

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P. SEITZER, Space Telescope Science Institute, Baltimore, U.S.A.

We have obtained high spatial-resolution CCD images in a night of excellent seeing of two of the five globular clusters (Clusters No. 2 and No. 3) in the Fornax dwarf-spheroidal galaxy using the NTT with the aim of extending their colour-magnitude (C-M) diagrams into their cores. The images, shown in Figures 1 and 2, were obtained with a high resolution RCA CCD (0.129″ pixel^{-1}) using EFOSC2. The average seeing (FWHM) for Cluster 3 was 0.″46 while that of Cluster 2 was 0.″58 in the Johnson V band. B band images were also taken. All exposures were of five minutes duration.

Figure 3 shows our instrumental C-M diagram for Cluster 2 based on preliminary reductions using DAOPHOT. This cluster has been resolved by NTT in both the B and V images for the first time right into the core. These data will be further improved by additional image processing to correct for regions of poor charge transfer. Even though our exposures are of only five minutes, already three times as many stars have been resolved and measured compared to the most recent published photometry by Buonanno et al. (1985) and nearly 10 times as many measured by Verner et al. (1981), both based mainly on a mixture of photographic and CCD photometry.

Our C-M diagram is sufficiently deep to reach the base of the horizontal branch and confirms the morphology of the metal-poor C-M diagrams obtained by both these authors but with a much higher degree of accuracy. Cluster 3, although observed in considerably better seeing than Cluster 2, was still not resolved to the core, but still yields a considerably better C-M diagram than has been previously done.

But what is so interesting about the Fornax galaxy globular clusters? Well, firstly, the Fornax galaxy is a dwarf spheroidal, and the only dwarf spheroidal known to contain a globular cluster system. It is therefore probably the least massive galaxy known to contain globular clusters. Five such clusters have definitely been identified (Hodge, 1961); a remarkably large number for such a low-mass galaxy. Secondly, Fornax is one of seven dwarf companions to our own galaxy and an obvious laboratory for comparing their chemical evolutions with both our own galaxy and those of the LMC and SMC.

Figure 2: *Fornax globular cluster No. 3 taken in the Johnson V band. The seeing (FWHM) was 0.″46 and the exposure 5 min. S is approximately up and E is approximately to the right. The cluster is not resolved to its core!*

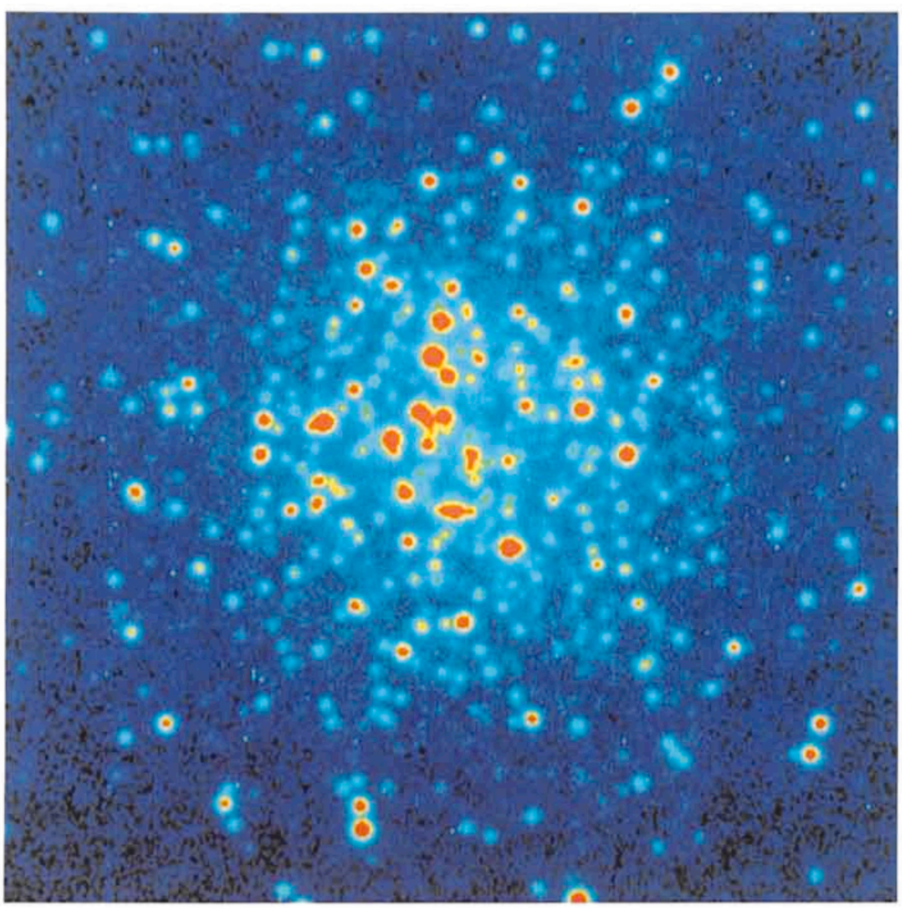


Figure 1: *False-colour CCD image of Fornax globular cluster No. 2 taken in the Johnson V band with EFOSC2 at the NTT. The seeing (FWHM) was 0.″58 and the exposure 5 min. S is approximately up and E is approximately to the right. This globular cluster is resolved to its core for the first time.*

The histories of the Fornax globular clusters are clearly complex since integrated light observations have shown that although their ages seem consistent with those of the galactic globular cluster population, their metal abundances of these clusters vary by a factor of about an order of magnitude (eg. Zinn and Persson, 1981). Moreover, there are significant mean metallicity differences between the Fornax clusters and those of the field stars. These clusters are therefore of interest and importance since they represent a sample all at the same distance but containing a large spread in metal abundance. These images also now enable us to study the structural parameters of the clusters, important for understanding their dynamical histories.

References

Buonanno, R., Corsi, C.E., Fusi Pecci, F., Hardy, E., and Zinn, R., 1985, *Astron. Astrophys.*, **152,** 65.

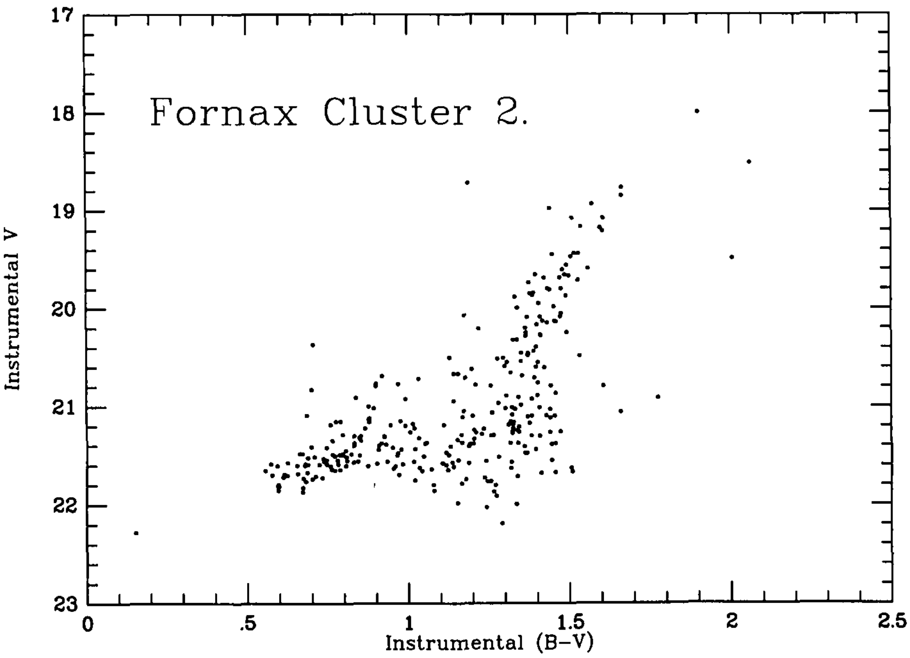


Figure 3: *Instrumental V vs B-V colour-magnitude diagram of Fornax globular cluster No. 2.*

Verner, G., Demers, S., Hardy, E., and Kunkel, W.E., 1981, *Astron. Astrophys.*, **86**, 357.

Hodge, P.W., 1961, *A.J.*, **66**, 83.

Zinn, R., and Persson, S.E., 1981, *Ap.J.*, **247**, 849.

Preparing for Comet Austin

Professional and amateur astronomers all over the world are excited about the prospects of seeing a really bright comet during the coming months. A newly discovered comet, known by the name of the amateur who first saw it, is now getting brighter each day. Observations are made almost every night at the ESO La Silla Observatory and elsewhere in order to follow the development of the comet and also to try to predict the maximum brightness which the comet will reach by mid-April this year.

Comet Austin – a Very Large Comet

When Comet Austin was discovered by New Zealand amateur Rodney R.D. Austin on December 6, 1989, it was already obvious that it must be an unusually large object. At that time the comet was still more than 350 million kilometres from the Sun and yet it was so bright that it was seen as an 11th magnitude object (that is, 100 times fainter than what can be perceived with the unaided eye).

More observations were soon made, establishing the comet's orbit and it was found that it will pass through its perihelion (the point of its orbit where it is closest to the Sun) on April 9, at a distance of about 53 million kilometres, inside the orbit of Mercury, the planet closest to the Sun.

Thereafter it will move outwards again and, by good luck, it will come within 36 million kilometres of the Earth on May 25. It will be well situated in the sky for observation from the northern hemisphere after April 20, when it can be seen low above the north-west horizon, just after sunset, and even better above the north-east horizon, shortly before sunrise. It is expected that Comet Austin will then have developed a tail which should be easily observable and provide spectators with a grand celestial view.

How Bright Will Austin Become?

One important question worries the astronomers. How bright will Austin actually become? Will it – according to the most optimistic predictions – become as bright as the brightest stars in the sky? Or will it "stall", much short of this goal, like the ill-famed Kohoutek comet in 1974?

At the centre of a comet is a "nucleus", a big chunk of ice and dust, with a diameter from a few hundred metres to several tens of kilometres. The diameter of the nucleus of Comet Halley was about 15 kilometres and that of Austin appears to be even larger. When cometary nuclei come close to the Sun, their surface ices evaporate due to the intense solar light. A surrounding cloud is formed – it is known as the "coma" – and also a tail that points away from the Sun.

A comet's brightness is determined by the amount of gas and dust in this cloud which in turn depends on the rate of evaporation from the nucleus. This rate is very unpredictable and accordingly, so is the comet's brightness. When theoretical predictions are uncertain, only observations can (perhaps) yield an answer.

Observations at ESO

For this reason, observations of Comet Austin have been carried out by ESO staff astronomers at the La Silla Observatory during the past months.

In concordance with observations elsewhere, a preliminary conclusion is that Comet Austin does have a good potential to become bright, but also that its current brightening, as it comes closer to the Sun, is "running slightly behind schedule". This is based on accurate photometric observations, carried out with the automatic Danish-SAT 50-cm telescope, accurately measuring the rate of brightening from night to night (see the article on page 55).

On the other hand, spectra of Comet Austin, obtained with the 1.52-m spectrographic telescope at ESO in mid-February, already show the strong emission of many different gas molecules in the coma cloud around the nucleus. Direct images from the 3.5-m New Technology Telescope in late January also showed a strong jet of dust particles, emanating from the nucleus. These observations clearly indicate that the evaporation process is well under way.

Finally, and rather significant, is the recent detection of a long tail of ions (electrically charged atoms) stretching more than 2 degrees in the direction away from the Sun. It was first seen on a photographic plate obtained with the ESO 1-m Schmidt telescope on February 25 under difficult observing conditions in the evening twilight, low above the horizon. A reproduction of this plate is shown on page 56.

However, another Schmidt photograph, obtained the day after, showed a much shorter tail. Thus the one seen on the photo was of brief duration and was probably caused by momentary interaction with a burst of rapid particles in the solar wind, not unusual at this time of maximum solar activity.

Predictions

The orbital computations indicate that Comet Austin appears to be a "new" comet, now approaching the Sun for the first time ever. The behaviour of "new" comets is much more difficult to predict than that of "periodic" comets who move in closed orbits and regularly pass near the Sun, like Comet Halley.

It is believed that new comets are covered by a thin layer of ices which begins to evaporate, already at a large distance from the Sun. Some of them may therefore be rather bright while still far from the Sun. However, when the deposit of ice is all gone, the brightness stalls; this is the most likely explanation for Comet Kohoutek's performance.

It remains to be seen how comet Austin will behave. In the best case it could reach magnitude −1 to −2 and rival the last bright comet, Comet West in 1976. It is perhaps more likely that it will reach magnitude 0, that is the same brightness as the brightest stars. In late April, when it is best visible from the northern hemisphere, it would then have magnitude 2, about as bright as the Polar Star. Presently, the most pessimistic predictions would put it at magnitude 2 at maximum, and 3.5 in late April.

This photographic image of comet Austin was obtained with the 40-cm double astrograph (GPO) at La Silla on February 26.0 UT. The 12-minute guided exposure shows the diffuse central area in which the cometary nucleus is surrounded by a dense dust and gas cloud. A diffuse dust tail points towards southeast (left, downwards) and the beginning of an ion tail can be discerned above it. Observers: H. Debehogne and R.M. West.

The best guess, based on the recent ESO observations, is the middle way. If that holds true, Comet Austin will indeed become a grand spectacle with a fine tail on the morning sky in late April. Since it approaches the Earth it will only fade slowly and we should be able to enjoy it all through the month of May.

But, of course, comets are notoriously unpredictable . . .!

(From ESO Press Release 04/90, issued on March 2, 1990.)

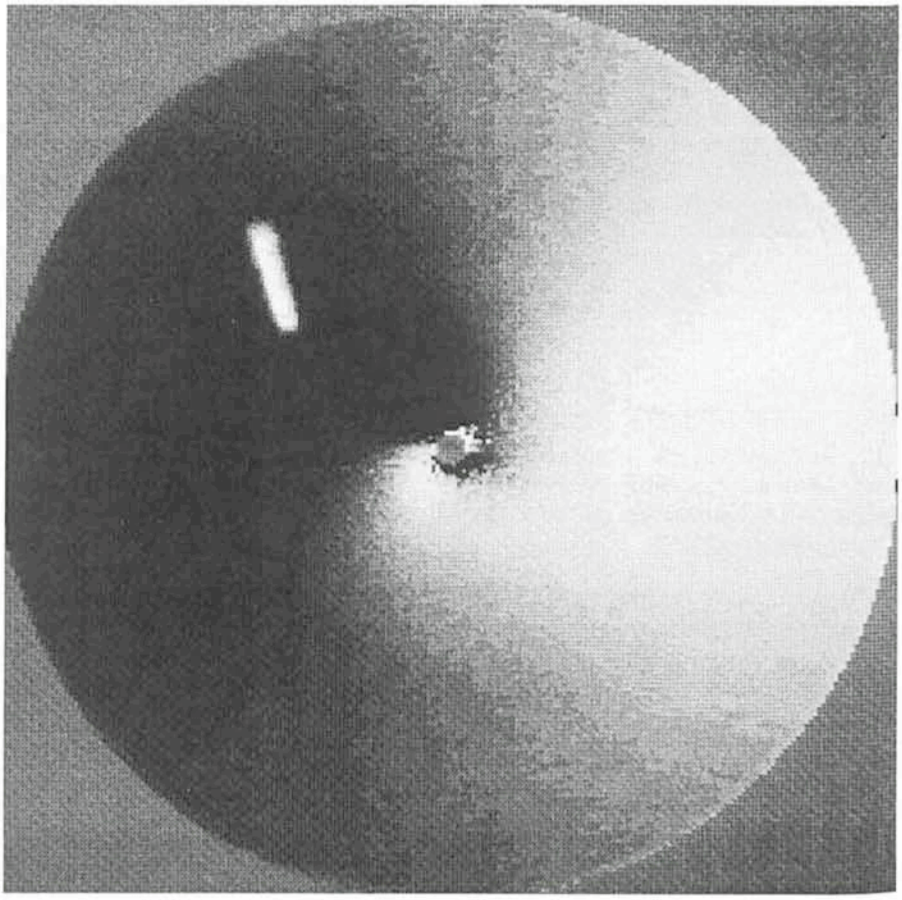
A Dust Jet From Comet Austin

On January 23, the ESO NTT was used during a short period of mediocre seeing (1.2 arcsec) to image Comet Austin. The direct, isophotal picture is shown on page 19 in this *Messenger* (where the image data are also given).

Image processing with the IHAP system at ESO Headquarters removed the symmetrical component of the cometary coma by means of the so-called radial renormalization method. The residual image, that is the asymmetrical component, clearly shows the presence of a comparatively bright, anticlockwise jet, emanating from the overexposed nucleus. It begins on the side which is facing the Sun and consists of dust particles which are released from the surface of the nucleus into space due to the heating effect of the Sun. The dust jet reflects the sunlight and can therefore be seen. On the date of exposure, the comet had not yet developed a real tail.

At this time, the comet was nearly 300 million kilometres from the Earth and at heliocentric distance 1.71 A.U. (255 million kilometres). The total magnitude was about 9.

Discrete structures have been observed in several comets at comparable or even greater heliocentric distances,



for instance faint sunward emissions were seen in P/Halley at 1.6 A.U. after perihelion in 1910. There are also reports about jets seen in P/Halley at more than 2 A.U. preperihelion in 1985. In 1955 a distant comet discovered by Baade displayed a sunward fan or streamer (but not a jet) at almost 4 A.U. from the Sun.

The presence of a jet in comet Austin at 1.7 A.U. preperihelion is not a very rare event among comets. Still, it is to be hoped that the activity observed already at this distance will continue through the perihelion passage on April 9, so that we shall have the opportunity to admire a really bright comet this spring.

R.M. West

Photometry of Comet Austin

J. MANFROID, Institut d'Astrophysique, Cointe-Ougrée, Belgium
P. BOUCHET and C. GOUIFFES, ESO

Strömgren photometry of Comet Austin (1989 c1) has been obtained at La Silla with the ESO-SAT 50-cm telescope, between February 12 and February 25, 1990. Two diaphragms were selected, 35 arcsec and 240 arcsec, in an attempt to distinguish between the nucleus and the coma.

Whenever possible, comet photometry is done with a special set of filters isolating molecular or ionic features, or the continuum. Hence different physical and chemical characteristics can be analysed. Our observing run was dedicated to stellar photometry. The SAT telescope is permanently equipped with one of the most appropriate photometric systems for that purpose, the Strömgren one. By design this cannot be changed.

Strömgren (uvby) photometry of comets is not uninteresting, however. Figure 1 shows a spectrum of Comet Austin obtained with the ESO 1.52-m telescope by P.B. and C.G. Superimposed are schematically indicated positions of the v, b and y passbands. The y filter includes a moderately strong feature of C_2. Hence the y magnitude is not too biased towards a special molecular emission or towards the continuum. In fact it is rather well representative of the visual magnitude (V). Studies of other comets (such as P/Halley) show a difference of only a few tenths of a magnitude between y and V. On the other hand, the b and v filters include strong bands of C_3 and C_2 respectively, and can be used in a study of those molecules.

Our main purpose was to monitor the brightness variations of Austin as it neared the Sun, in order to get a more precise idea of its appearance in April and June, when it is most favourably placed for astrophysical observations. The evolution of the apparent magnitude of a cometary coma is usually written as

$$m = M + 5 \log \Delta + 2.5\, n \log r \qquad (1)$$

where M is an "absolute" magnitude (which would be observed if both r and Δ were equal to 1 A.U.). n is a parameter depending on the evolution of the comet. Obviously that law was adopted because n apears to be constant during relatively long time intervals. For most comets this parameter lies between 2 and 6. The precise value is important in order to get accurate predictions, as shown by equation (1).

The origin of the 5 log Δ term is simple. It reflects the apparent size increase of the coma, which is inversely proportional to the square of Δ, assuming no intrinsic variation. This is all right when one integrates the brightness over the whole object. But this is not what we did, we used fixed apertures and equation (1) does not hold. Let us consider two limiting cases. Firstly, the aperture is very large and contains the whole coma. Then we are back in the conditions of relation (1). Secondly, the aperture is so small that we see the peak value of the nuclear surface brightness. This maximum value is of course a constant. Hence it would show no Δ dependency. The relevant equation would be

$$m = M + 2.5\, n \log r \qquad (2)$$

We are somewhere between those two cases. Applying relation (1) we find values of 2.6 and 2.3 for n (respectively for the 35 and 240 arcsec diaphragms). Applying (2) instead, we find 3.5 and 3.0 (see Fig. 2a and Fig. 2b). We may assume that the small diaphragm magnitudes better follow law (2) (n = 3.5), and that the large diaphragm encompasses most of the coma, so that the derived magnitudes obey law (1) (hence n = 2.3). This is a very crude approximation but it tends to show that the overall integrated brightness does not rise as fast as foreseen. The predicted values around 5 were probably too optimistic. On the other hand the nuclear region seems to brighten more rapidly. This is confirmed by the telescopic aspect during the 13 days interval of our observations.

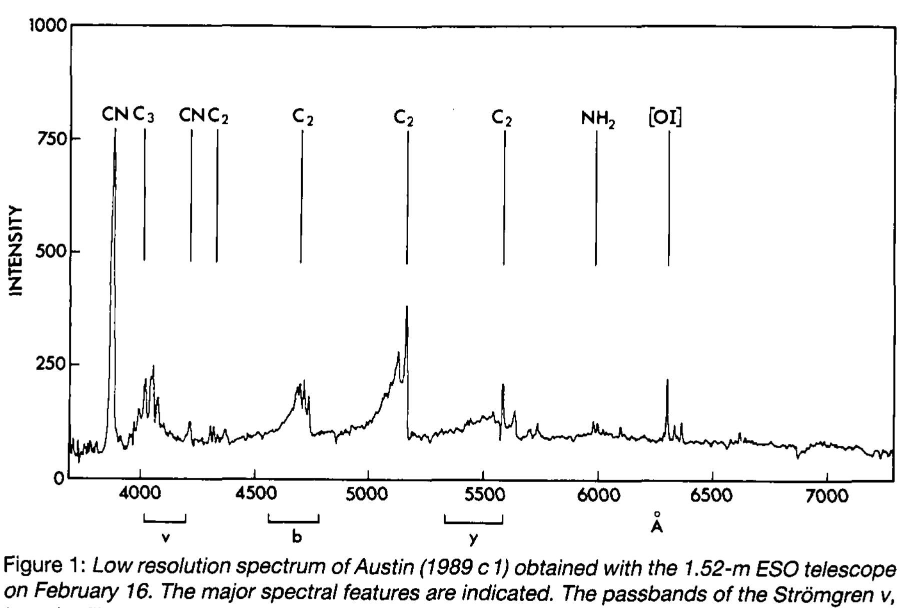


Figure 1: *Low resolution spectrum of Austin (1989 c1) obtained with the 1.52-m ESO telescope on February 16. The major spectral features are indicated. The passbands of the Strömgren v, b and y filters are shown below.*

TABLE 1. Strömgren photometry of Austin (1989 c1)

Date	u	v	b	y
Diaphragm 240 arcsec.				
Feb 13.0	10.95	10.11	8.83	8.61
15.0	10.54	10.01	8.73	8.55
16.0	10.21	9.84	8.55	8.44
17.0	10.52	10.01	8.63	8.50
18.0	10.43	9.98	8.56	8.40
21.0	10.41	9.88	8.40	8.24
22.0	10.27	9.79	8.33	8.17
23.0	10.16	9.75	8.26	8.09
24.0	10.22	9.69	8.20	8.04
25.0	10.11	9.62	8.18	8.03
Diaphragm 35 arcsec.				
Feb 12.0	12.36	11.56	11.03	10.75
13.0	12.64	11.69	11.05	10.76
15.0	12.32	11.72	10.87	10.59
16.0	12.05	11.37	10.79	10.53
17.0	12.30	11.34	10.73	10.46
18.0	12.12	11.29	10.65	10.39
21.0	11.91	11.16	10.57	10.31
22.0	12.21	11.22	10.51	10.27
23.0	11.86	11.03	10.33	10.08
24.0	11.97	11.09	10.35	10.11
25.0	11.95	10.98	10.28	10.05
Accuracy:	.15	.10	.06	.03

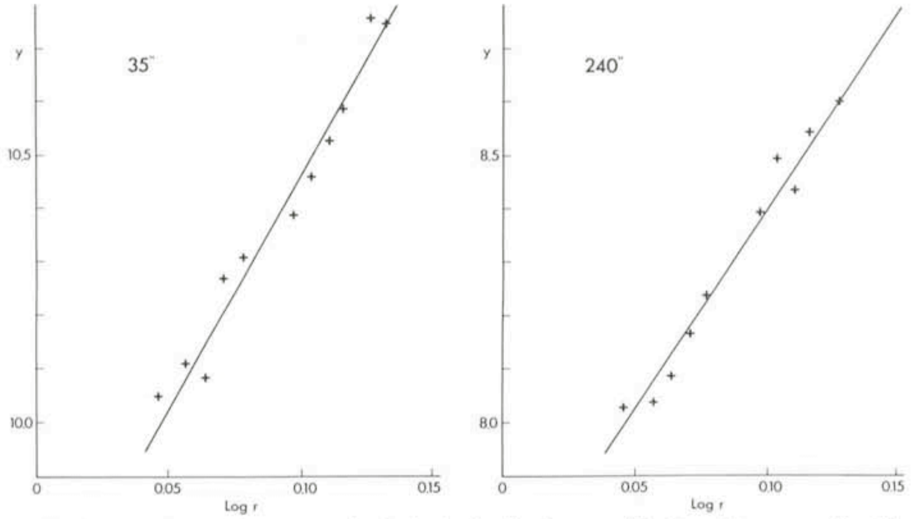


Figure 2: *Variation of the y magnitude in both diaphragms (Fig. 2a, 35 arcsec, Fig. 2b, 240 arcsec) as a function of log r. These graphs allow to derive the values of n according to law (2).*

Those conclusions are still uncertain. During that time lapse the distance comet-Sun (r) decreased from 1.36 to 1.12 A.U. while the distance comet-Earth (Δ) decreased from 1.83 to 1.69. Those relatively limited ranges do not permit a reliable extrapolation. Moreover we are neither in case (1) nor in case (2). An elaborate model of the coma would be needed to derive more appropriate laws. Unfortunately Austin will now cease to be measurable during several weeks, and we will have to wait until mid-April, when the comet moves into the morning sky, to see if it really becomes a Great Comet.

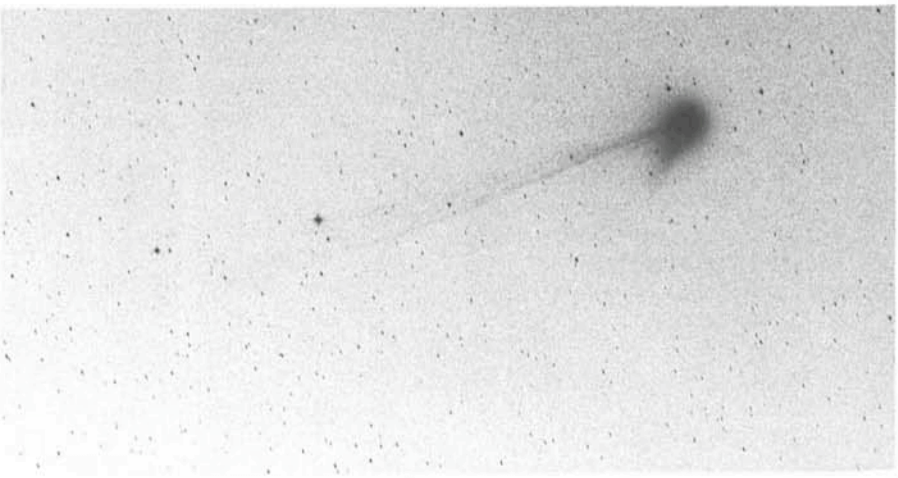
Comet Austin Develops an Ion Tail

The upper photo is a reproduction of a photographic plate, exposed 6 minutes with the ESO Schmidt telescope at La Silla in the evening of February 24, 1990 (Feb. 25.0 Universal Time). It was made on blue-sensitive emulsion during evening twilight, only 15° above the horizon. The telescope was set to follow the comet's motion; this is why the images of stars are trailed. The reproduction has been photographically amplified to bring out better the details in the faint tails.

There are two tails. The short, stubby one consists of dust particles reflecting the light from the Sun; it measures about 20 arcmin. The narrow ion tail mostly shines in the light of CN and CO_2 molecules; it is more than 2° long. It has the appearance of a double helix with at least two cross-over points and several wiggles. The shape is determined by the deflection of the electrically charged ions in the interplanetary magnetic field which is in turn influenced by the intensity of the solar wind.

The photo below was obtained one day later, on February 26.0 UT. The exposure time was now 12 minutes, but the ion tail is shorter. This indicates that the event which caused the long tail the day before, must have been transitory. Probably Comet Austin encountered a "magnetic border zone" in interplanetary space, where the magnetic field, carried by the solar wind, abruptly changed intensity and/or direction.

The plates were obtained on IIa-O emulsion behind a GG 385 filter, the observers were Hans-Emil Schuster and Guido Pizarro, and the photographic work was made by Herbert Zodet.



Status Report on EMMI: Results from the Testing in Garching

H. DEKKER and P. MOLARO, ESO

In the *Messenger* No. 57 of September 1989 a status report on EMMI was given at the start of the integration and test period. This period has now been concluded; at the time these lines are written the instrument is about to be packed and shipped to La Silla. The integration of the instrument in the NTT Nasmyth room B will take place this spring. Installation at the telescope will take place as soon as the second adaptor/rotator of the NTT is fully tested at the end of June and a first period of tests on the adapter is scheduled for July. We describe here some of the results obtained during the tests in Garching.

The image quality is a complex function of focus, position on the CCD and wavelength (because of secondary colour in the lens optics) so it is difficult to give a single number. In general, image quality in the red arm is at the level of 10–25 μm. EMMI was tested and will be initially used with the red F/2.5 camera and 1024 ×1024 Thomson 3156 chip. The blue optics are now in the last phase of assembly at the manufacturer. We intend to fit the blue F/4 camera and a coated Thomson chip during the integration on La Silla. With these cameras, the pixel matching will be 0.45 (red) and 0.28 arcsec/pixel (blue). The experience with EFOSC2 (matching .15–.25 arcsec/pixel, depending on the detector mounted) has shown that image sampling at this scale is necessary if we are to exploit the not-too-rare periods of excellent seeing at the NTT. For direct imaging in the red we are considering the option of a second long camera. For instance, the F/5.3 camera combined with a Tektronix 1024 × 1024 chip with 24 μm pixels will provide a matching of 0.27 arcsec/pixel and a field of 4.5 × 4.5 arcmin at the expense of reduced wavelength coverage in grism spectroscopy. Another possibility would be a 2048 × 2048 Ford CCD with 15 micron pixels. The decision for a high resolution red camera/CCD option will be taken later this year depending on a number of mainly operational considerations.

EMMI being a multipurpose instrument, the light meets more optical surfaces than would be necessary in a dedicated instrument. This was one of the reasons for splitting the instrument in two channels in order to enable the use of optimized multilayer coatings. As an example of what can be obtained with these coatings, the on-axis transmission of the red medium dispersion collimator is shown in Figure 1. From measure-

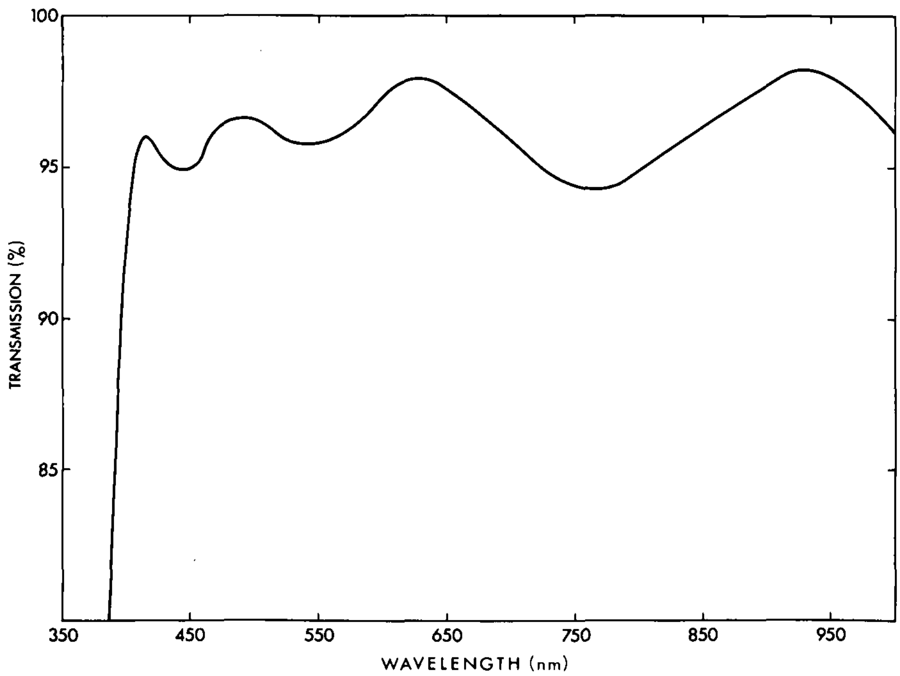


Figure 1: *The transmission of the red collimator (consisting of two cemented doublets) in single pass. It is used in double pass, so the total efficiency in the range 4000–10000 Å will be over 90%, still better than a single aluminium mirror.*

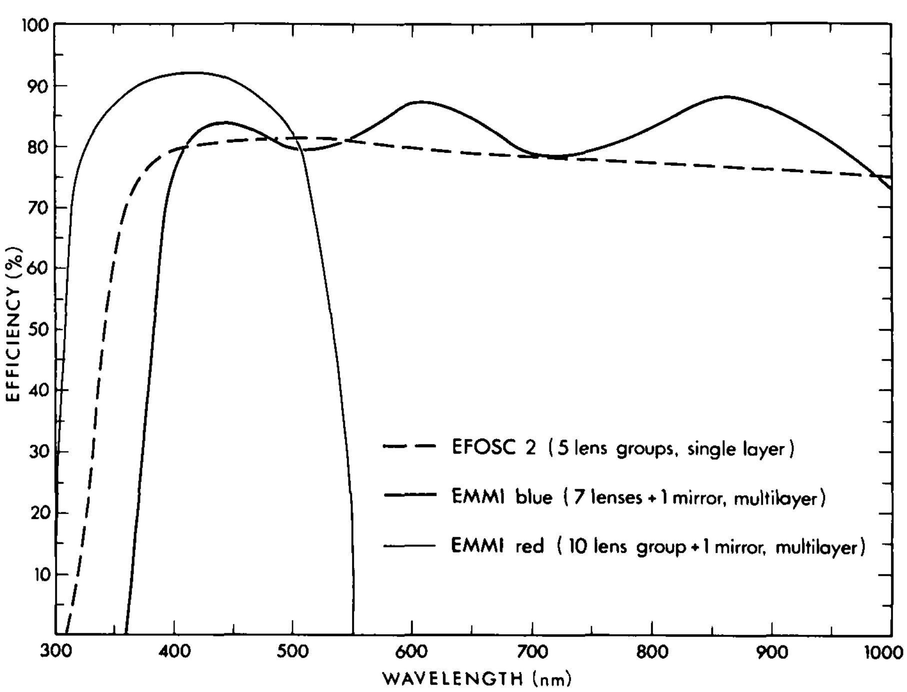


Figure 2: *The efficiency of the EMMI optics in imaging and low dispersion as compared with EFOSC2.*

ments of the optical units we calculate an overall efficiency of 85 and 70% in the red imaging/low dispersion and medium dispersion modes respectively; somewhat better in the corresponding blue modes. EMMI is in each of these modes more efficient than the competing 3.6-m instruments EFOSC, Boller & Chivens or Caspec. Figure 2 compares the efficiency of EMMI in imaging and low dispersion with EFOSC2.

Ghosts and stray light are very low. Lens optics in spectrographs have a well-known disadvantage which is the possibility of spurious reflections. With modern optical design programmes such ghosts can be accurately predicted and – by adjusting the design parameters – reduced to insignificant levels. In fact, the only noticeable ghost occurs at a cemented interface in the collimator which has a reflectivity of .01% and had not been considered in the ghost analysis.

EMMI will be mounted at the adapter of the NTT and is co-rotating to follow the field rotation. Rotation rates when tracking near the zenith will be much higher than the 15 deg/hour experienced by instruments at equatorial telescopes. Our design specification for flexure calls for an image motion on the detector of less than 10 μm in the dispersion direction when rotating the instrument by 180 degrees, a very hard requirement in view of the large number of moving functions and the size of EMMI. A typical assignment within the image motion error budget calls for a contribution of 2 μm due to any particular function. For the grating unit this translates into a maximum admissible flexure of just 0.4 arcsec on the grating surface when turning the unit upside down! The structure of EMMI, the grating units as well as many other critical units were each individually tested and many improvements were made in order to meet this objective. Further flexure tests of the complete instrument will be carried out at the telescope.

EMMI was controlled by an engineering version of the control software which was continuously improved during the test period. A first version of the user interface with softkeys and forms on the Ramtek monitor was also tested. We used a Thomson 1024 × 1024 setup chip mounted on the red arm, controlled by the new VME camera and a standalone version of the new CCD programme, a configuration sufficient for the Garching tests. All in all, the integration and test of EMMI in Garching proceeded very smoothly and without major negative surprises. Still, a substantial amount of work remains to be done for the integration of the EMMI hard- and software with the NTT environment.

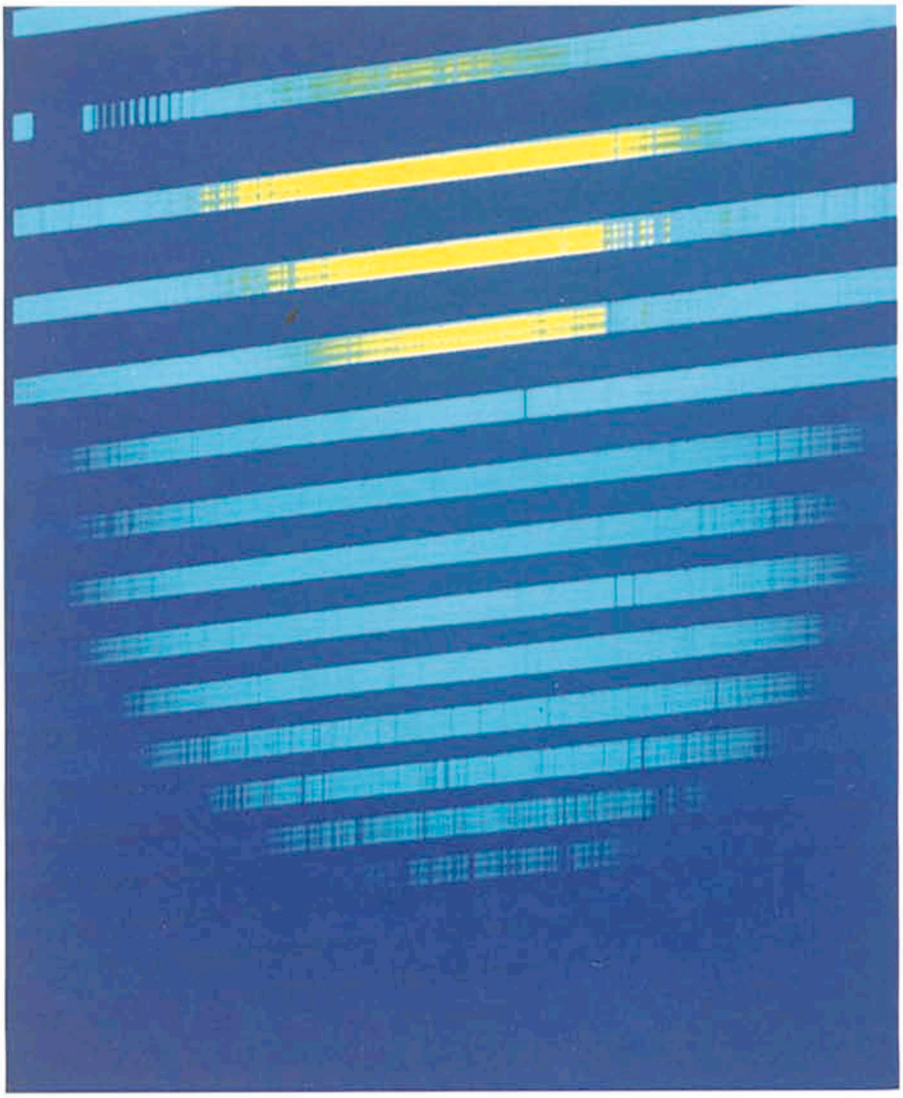


Figure 3: *The echelle spectrum of a nearby G-type star taken with EMMI from Garching. Note the strong O_2 bands in orders 20 and 23 caused by the large airmass and low altitude.*

As an appetizer for future users, we show in Figure 3 an echelle spectrum of the Sun (probably the first solar spectrum ever recorded from Garching) taken with a 3-cm telescope and a 35-m fiber link. This sun spectrum gives a first impression of the quality of the data that can be obtained with this instrument. Note that echelle spectroscopy is a demanding application; focus and image quality must be optimized in a large wavelength range over the complete CCD field and stray light and ghosts are most apparent in echelle mode.

The spectrum has been recorded using a slit with a width of 0.5 arcsec and a height of about 17 arcsec (38 pixels) that was illuminated along its full height by diffused sunlight from the fiber. A star spectrum would appear much narrower depending on the seeing and tracking accuracy. In the figure, red (up to 7700 Å) is at the top and blue (starting at 4000 Å) at the bottom. The figure does not display the whole CCD because the image has been truncated to eliminate two dead columns on the right side of the setup chip. However, this does not cause any spectral gap since the adjacent orders overlap for about 90 Å each side. Expert eyes can recognize at a glance the atmospheric A and B O_2 bands in orders 20 and 23 (the first and the fourth order counting from the top), H_α at the centre of order 24, the D_1 and D_2 resonance lines of NaI on order 27, the MgIb multiplet at $\lambda\lambda \approx 5170$ Å in order 31 and H_β in order 33.

Figure 4 displays a portion of the extracted and wavelength calibrated order 24. Background has been evaluated averaging from the two adjacent interorders and subtracted. The calibration in wavelength has been performed using an image of a Thorium/Argon lamp taken with the same set-up. Then the order has been normalized with a spline interpolation through continuum windows. To check the photometric accuracy we have measured the equivalent widths of the strongest lines, not contaminated by water-vapour lines. The comparison of our equivalent widths with those of the Moore et al. (1966) solar atlas, paying attention to add all the possible contributions, has shown an agreement within ±0.004 Å, and without systematic trends. Such a small difference can be easily accounted for considering the uncertainty in the drawing of the continuum and the accuracy of the measurements in our spectrum that has a S/N of ≈200.

The level of the scattered light measured in the interorder region stays fairly low all over the CCD and in the red it remains below 2% of the nearby order intensity.

The spectral resolution measured from the arc image is slightly varying from one order to the other likely due to non-perfect focusing over the entire wavelength range. The best resolution is found in order 28 where the average FWHM of the arc lines is 0.48 Å giving a resolving power of ≈ 12,000. This is what one expects taking into account the Rs product of this grating (7700 for a 1 arcsec slit), the slit width (0.5 arcsec) and pixel size (0.45 arcsec).

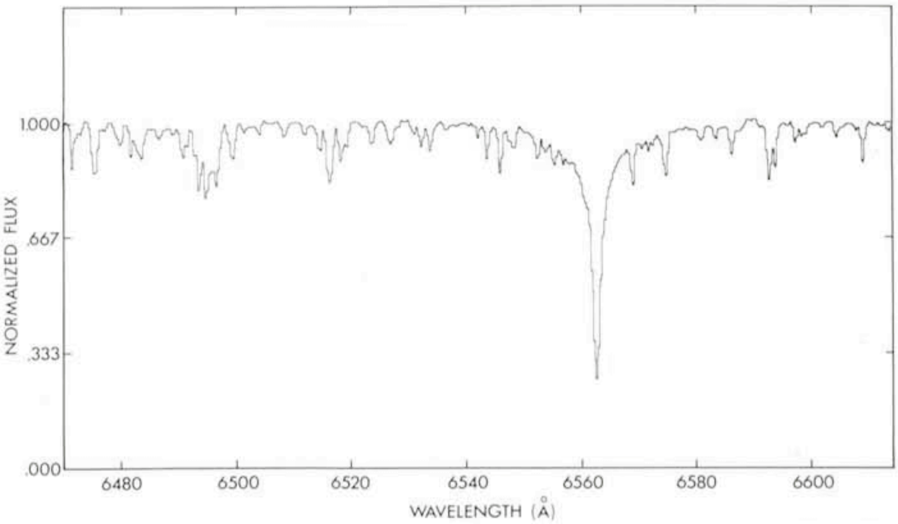


Figure 4: *A portion of order 24 extracted from the echellogram of Figure 3 showing the region around H_α.*

References

Moore, C.E., Minnaert, M.G.J., Houtgast, J.: 1966, *National Bureau of Standards Monograph,* **61.**

The Thomson 1024^2 Pixel CCD at the New Technology Telescope

S. D'ODORICO, ESO

Many of the guests who admired on the recent inauguration the impressive images taken with the NTT telescope (see the leading article in this issue of the *Messenger* and Fig. 1) were probably not aware that one of the most important components in the chain that produced those results is a 19 × 19 mm silicon device, a 2D detector usually known as a charge-coupled device or in short a CCD, and its associated electronics.

CCDs are nowadays the more intensively used detectors in astronomy because of the convenience of their digital output, the precise geometry of their discrete elements, the good linearity and uniformity, the high quantum efficiency and the low values of the intrinsic sources of noises such as read-out and dark current. At ESO, the six largest telescopes are now equipped with CCD cameras for imaging and spectroscopy and they are used in these modes for the largest fraction of the observing time.

Several industrial companies produce CCDs of interest to astronomical applications: those who currently deliver chips which are in regular use at different telescopes are Thomson CSF and EEV in Europe and Tektronix, Texas In-

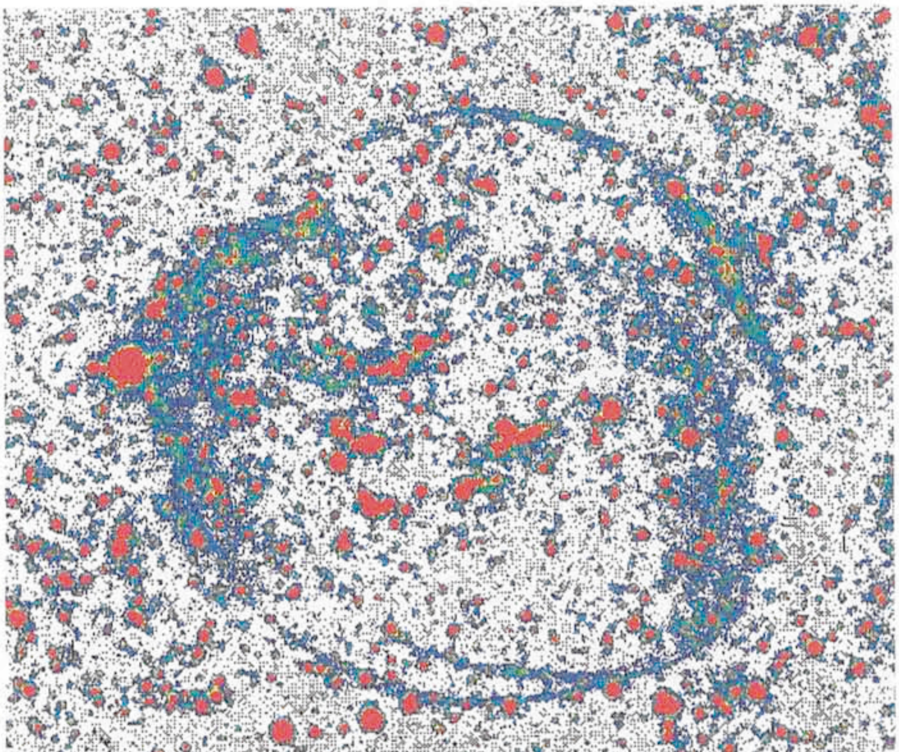


Figure 1: *A 30-minute exposure of the Balmer-line dominated supernova remnant 0548-70.4 in the LMC taken at the NTT with EFOSC2 and the Thomson 1024^2 pixel CCD in the light of $H\alpha$ and [N II]. In this false-colour reproduction, objects of higher intensity, both stars and nebulae, are shown in red. The field is 2.6 × 2.6 arcmin with a sampling of 0.152 arcsec/pixel. The low read-out noise of this CCD device (<10 e^-/pixel) is an important asset for this kind of observations where one wants to detect faint features against a relatively low background.*

strument and EG & G Reticon in the USA.

While many of these devices show excellent properties, they hardly fulfil the desiderata of astronomers either in term of size (they are just too small!) and of other working parameters. In one of many initiatives to foster the development of better devices for astronomy, ESO joined INSU of France in 1988 to support the production of 1024 pixels, front-illuminated CCDs by Thomson CSF.

Three devices of this type (TH 31156) were delivered to ESO during 1989 and they were intensively tested in the ESO detector laboratory. One was installed on the EFOSC 2 focal reducer at the NTT in December 1989. It had been previously coated at ESO with laser dyes to enhance the UV-blue quantum efficiency. Figure 2 shows the final efficiency curve. The other characteristics of this CCD, now designated as ESO # 17, can be summarized as follows: r.o.n = 6 e^- pixel, dark current at 140 °K 30 e^-/pix/hr, high charge transfer efficiency, linearity over a dynamic range of 10^5, cosmic events rate 1.5 events/cm^2/min, saturation level of one pixel 1.6 10^5 e^-, absence of any major blemish. These properties make the TH 31156 CCDs a good choice for a wide range of observing programmes and explains why devices of this type have now also been introduced at the AAT 150-inch and the Tololo 4-m telescopes.

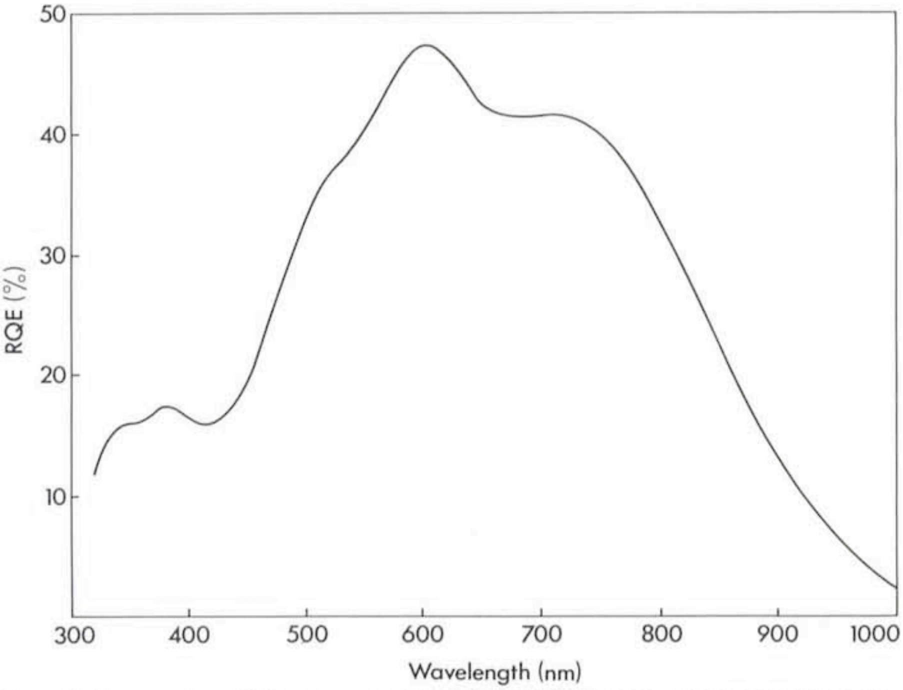


Figure 2: *The quantum efficiency curve of the TH 31156 CCD (ESO # 17) after coating in the ESO laboratory.*

The December 1989 commissioning run at the NTT represented also the culmination of two other important developments carried out at ESO in the field of optical detectors. The CCD was installed with a new, versatile control camera based on commercially available VME-bus boards and on custom-made boards interfacing the CCD to the VME-bus. The camera (Reiss et al. 1989, SPIE Vol. 1170) was developed in the ESO electronics lab in the last three years and finds a wide range of applications in present and future ESO instruments.

The CCD was installed in the dewar on a new front-end also designed at ESO for use with CCDs as large as 6 × 6 cm (Fig. 3). Other novel features of the new mounting are the location of the pre-amplifier board close to the chip to minimize the system noise and various artifices adopted to maximize the thermal insulation and to facilitate a precise spatial adjustment of the chips.

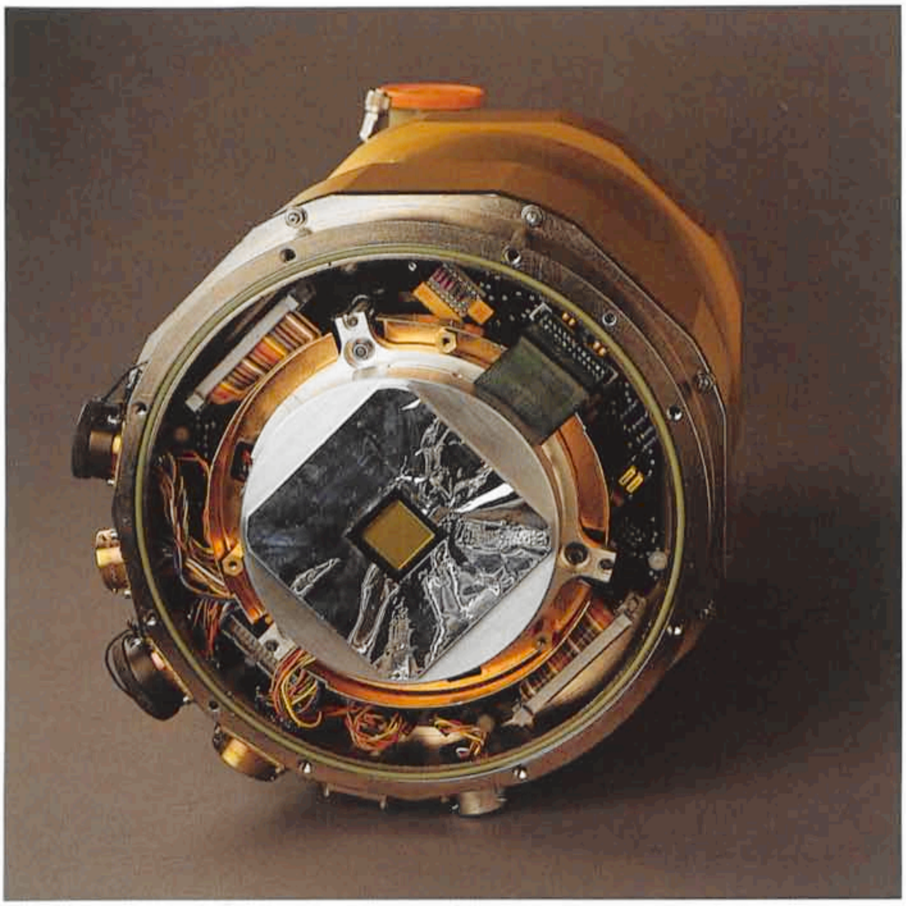


Figure 3: *A view of the TH 31156, 1024^2 pixels CCD on the new mounting designed and realized at ESO. With a 2.3-l liquid nitrogen tank, the dewar can operate the CCD at the required temperature of 140 °K for periods longer than 24 hours without refilling.*

First Announcement

HIGH-RESOLUTION IMAGING BY INTERFEROMETRY. II

From 15 to 18 October 1991

European Southern Observatory
Garching bei München, F. R. Germany

Chair: **J. M. Beckers and F. Merkle.** For further information contact "Interferometry 91", c/o Christina Stoffer at ESO, Karl-Schwarzschild-Strasse 2, D-8046 Garching bei München, F. R. Germany.

The European Science Data Archive for the Hubble Space Telescope

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[1] Space Telescope European Coordinating Facility, ESO
[2] Affiliated with Astronomy Division, Space Science Department, ESA
[3] On leave from Osservatorio Astronomico, Trieste, Italy
[4] European Southern Observatory
[5] Now at Space Telescope Science Institute, Baltimore, USA
[6] Now at Dipartimento Scienze Fisiche, University Naples, Italy

Introduction

In the framework of the cooperation between NASA and ESA on the Hubble Space Telescope (HST) project the archiving of the science data have always been ranked high in priority. Not only will it be very difficult to apply for and obtain observing time on HST (as those who participated in the first round of observing proposal submission can confirm), the utilization and optimum exploitation of these very expensive data sets can only be achieved through archival research. This has been demonstrated through the very successful de-archival programmes operated by the IUE data archive.

Initially HST data will be archived at the ST Science Institute (STScI) in the Data Management Facility (DMF) on optical disks. As these disks are being produced, a second copy is made and is shipped to the ST European Coordinating Facility (ST-ECF) immediately. This means that the ST-ECF will get a full copy of the HST archive immediately after the observations are carried out. The implication of this is that the ST-ECF had to build a near identical archive with equivalent data retrieval capabilities and security measures: as is well known, HST data will nominally remain proprietary for a period of one year after the end of the respective observing programme, with some exceptions.

The HST Science Data Archive of the ST-ECF was designed and implemented in collaboration with ESO and with the STScI. Realizing that during the projected life time of more than 15 years it would not be possible to maintain hardware compatibility, emphasis was placed on a design which would allow software and data compatibility even on different hardware configurations.

The logical configuration of the two archive facilities (DMF at STScI and Science Data Archive at the ST-ECF) was designed during 1985, and mapped into available hardware. Initially the two hardware architectures were similar, but this changed as time passed. The software elements were identified, and STScI and ST-ECF agreed to assume responsibility for the development of the various parts of the system; in addition, site-specific utilities were developed in both places. Around 1987 the Canadian Astronomy Data Centre (CADC) at Dominion Astrophysical Observatory decided to build a similar archive and participated in the development through discussions and collaboration.

It should be noted that the DMF at the STScI is considered to be an interim facility. Its functions will be taken over by the Data Archive and Distribution System (DADS), which is currently in the early planning stages. This changeover is expected to occur not earlier than 1993. As far as the ST-ECF is concerned, the Science Data Archive is the European HST archive during the lifetime of the mission. Interface control documents have been negotiated to make sure that continued data transfer will be possible.

Archive Requirements

The HST will produce formidable amounts of data, with more to be expected when the second-generation scientific instruments go into operation in the mid-1990's.

Currently we expect 1-2 Gbytes of data per day, which roughly translates into about an optical disk platter per day. As mentioned above, these data sets will be shipped to the ST-ECF soon after the observations were taken.

Part of the information, the observation catalogue (i.e. the information contained in the header of the sets) will get sent to the ST-ECF in near real time via computer network. For this purpose we recently installed a dedicated link to ESOC Darmstadt in order to connect to the NASA Network using also TCP/IP. In addition, SPAN can be used as long as both archives are using VAX computers. This ensures that information on what has been observed can be made available to European astronomers as soon as possible.

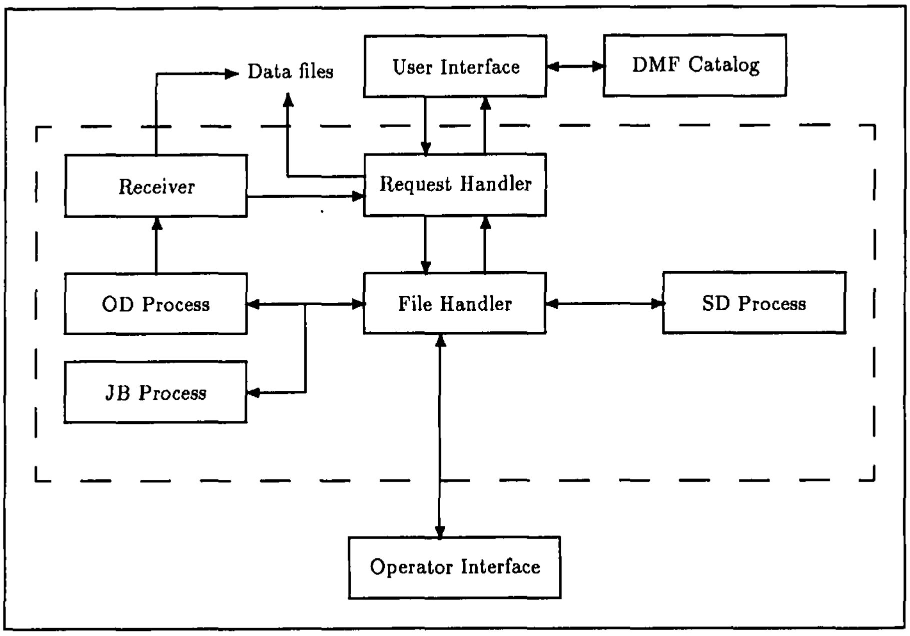


Figure 1: *Software structure showing system components and their interrelations.*

Archive Hardware Design

The archive hardware system is designed following the client-server model: it consists of an archive server (holding the mass storage devices and taking care of bulk data handling), and of a catalogue server, allowing efficient access to the HST catalogue of observations and to some astronomical catalogues, to be used for scientific support. No user accounts are maintained on the archive and the catalogue servers, both for decoupling system work from standard user work, and for archive security reasons. User access (local or remote) to the HST archive and catalogue is guaranteed on other computers in a LAN, acting as clients.

At the ST-ECF, the archive server is a microVAX II/VMS computer, connected to the ESO/ST-ECF LAN and equipped with standard magnetic media (magnetic tape, 1.8 Gbytes of staging disk area). Four optical disk units (an Alcatel-Thompson Gigadisk, two LMSI Laserdrive 1200 s and a Maxtor 800) can be used to physically store the data.

Currently acting as the catalogue server there is a Britton-Lee IDM 500 database machine, running the OMNIBASE/IDM software, and accessible from the archive microVAX and from one of the two clustered 8600 VAXes connected to the ESO/ST-ECF LAN. This device is currently being replaced by a more efficient system based on a general-purpose computer (a Sun) and a commercial data base management system (DBMS), selected after benchmarks and comparisons between different DBMS's have been made, in close collaboration with ESO/IPG.

An 8-mm cartridge tape device has recently been made available to allow a cost-effective eventual distribution to users of large quantities of data. The helical scan technology is currently developing fast, so it is likely that other devices will be purchased, after the community of users has been contacted. The upgrade of the microVAX itself with a more efficient system is being considered, although with low priority at this time.

Archive Software Architecture

As already mentioned, a software system for the archiving of HST data has been built in a joint effort between STScI and ST-ECF: the File Handler and related processes, database and network interfaces were developed at the STScI, the User and the Operator Interfaces and the Request Handler were written at the ST-ECF. The User and the Operator Interfaces are layered on the Proteus/TermWindows software (P/TW), developed as a collaboration between ST-ECF and ESO/IPG.

STARCAT (Space Telescope ARchive and CATalogue) is the user interface to the HST archive: it can be accessed from any terminal in ESO/ST-ECF, and through computer links from remote sites. STARCAT is the way of accessing the HST catalogue and other catalogues available for reference which are stored on the catalogue server. It is the only part of the system actually visible to the user, therefore it has been built in such a way that it is easy to use: there is no command syntax to learn, and catalogue queries can be issued through a form-filling mechanism. It can be considered as a stable software product, since it has had lots of feedback from the astronomers' community. De-archiving requests can be issued from STARCAT, and are managed by the Request Handler. Actual manipulation of files, including OD handling, is taken care of by the File Handler and its processes, which rely on the Operator Interface for exchanging messages with the system operator(s). All of the components of this rather complex system are different processes, some of them running on different computers, and connected to each other by NET, the network interface.

All of the code has been written to be portable through different operating systems, DBMS's, network protocols. VMS and Unix implementations are available for STARCAT, catalogues have been integrated in the IDM and Sybase systems, and network connections have been using DECnet and TCP/IP protocols.

Software developments at the ST-ECF will consist in improvements to STARCAT (in collaboration with ESO/IPG), and in software developments for the rest of the system (in collaboration with STScI and CADC). In particular, only the STARCAT side of this exercise will be of relevance to the user, since it involves the interface the archival researcher will find when dealing with the system; the other upgrades of the software will handle the kernel of the system (being mainly relevant to operator-related operations) and therefore will be transparent to users.

Archive Operations

As mentioned above, the observation catalogue will be accessible to on-site and off-site users through computer networks. This will normally not be true for the data, except maybe in the case of spectral data (several 10**3 bytes), which could be transmitted at least locally.

However, the main reason (in addition to bulk) why the data will normally not be available on-line is the fact that it is indeed difficult to keep them on-line. To make a year's worth of data available on-line would require a robotic arrangement able to handle in the order of 500 12-inch platters. Not only would this require a substantial amount of money, it is also very difficult to plan in the absence of operational experience. Thus it is foreseen to initially perform the actual de-archiving of data through operator intervention; this also provides an additional measure of data security.

Before accessing the HST catalogue, an identification phase will be needed: browsing the catalogue, a free-of-charge activity, will require just selfregistration, while data retrieval will require privileged ST-ECF staff intervention, if involving costs for the user.

Scientists will use STARCAT to browse through the HST observations catalogue and, through its form-filling mechanism, to identify and select data of interest. From within STARCAT, users will then issue a de-archive request which will be verified for validity, existence and proprietary status of data, and available user credit, and finally queued for operator action. STARCAT can then be left, and the system will notify completion of operations via an e-mail message.

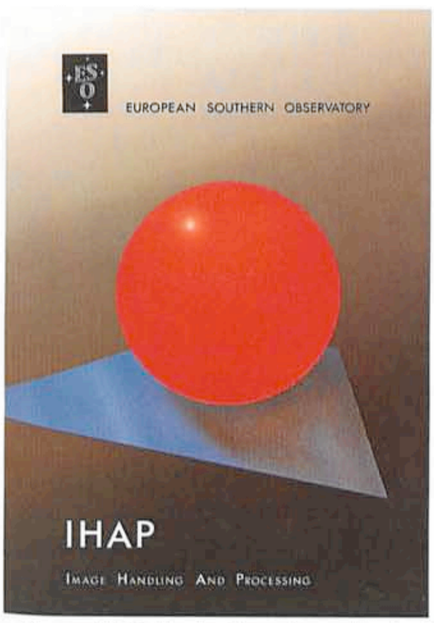
When the files are retrieved, they will be directly delivered on the user's data analysis work area on disk, if at ESO/ST-ECF; otherwise, a hard medium will be produced. Magnetic tapes are currently supported; upon special request, data can be shipped also on 8-mm cartridge tapes or Maxtor 5" 1/4 WORM OD's. As the market develops, other storage media are likely to become available.

Current Status

At this time the hardware elements of the archive are in place and the software has been developed. An end-to-end test of a data transfer from the HST (at that point it was located in a clean room at Lockheed) through the NASA system, through the DMF at the STScI, into the ST-ECF Science Data Archive was carried out earlier in order to verify that the planned transfer will indeed work. An archive readiness review was held at the STScI in mid-November. At the present time we are going through the final preparations for launch. The overall archive system is being exercised at the ST-ECF, before the first HST data are available to users (roughly 7 months after launch time), on the IUE LBL archive, to get a feeling of what day-to-day dearchival operations on the HST archive will look like.

Acknowledgements

The HST archive system has been designed and implemented in close collaboration among STScI, ST-ECF, ESO and, more recently, CADC; all of the staff at these sites participating in this effort are herewith acknowledged. In particular, we would like to mention Leslie Hunt and Sergio Restaino, who have contributed to this project at the ST-ECF.



A new IHAP User's Manual, version April 1990, is available:

- the command description is alphabetically ordered
- it contains all updates since March 1985
- more introductions are given
- reduction methods for 2-D spectra are described
- the manual was revised by M. Véron (OHP), D. Baade, P. Grosbøl (ESO) and others.

The technical details of IHAP are described in a new IHAP "Engineering Manual". Please contact Ch. Euler for these new manuals.

IHAP is mostly used at La Silla where HP/1000 computers control telescopes (including the NTT), instruments and detectors.

P. Biereichel

MIDAS Memo

ESO Image Processing Group

1. Application Developments

Since December 1989 the Portable MIDAS has finally become the default version within ESO on the VAX/VMS machines. This led to a heavy workload of fixing bugs and ironing out problems all over the system. We now have a much more stable system and many minor improvements and additions have been included. No major new applications have been added in the meantime, except some new algorithms in the LONGSLIT package.

2. System Developments

Most UNIX workstations running MIDAS do not have their own tape unit but must share a common network tape station. A remote tape server task is now available for UNIX systems using TCP/IP protocols. When installed, it enables the tape commands in MIDAS to access a remote drive as if it were a local device. The interprocess communication interfaces have been rewritten and now use sockets instead of pipes. Therefore, they should be more portable and work also on pure BSD machines, e.g. Alliant.

3. Better Support of DECwindows Under VMS

The portable MIDAS is supported on both VAX/VMS and UNIX systems. To ensure full compatibility of MIDAS with the latest release of VAX/VMS, a VAX station 3100 running VAX/VMS was purchased by the Image Processing Group. This system will be kept updated with respect to the VMS operating system and the DECwindow X11 based display manager. New releases of MIDAS will be verified on this VAX station and thereby certify them for the full range of VAX/VMS systems. The IDI server (the programme which manages the MIDAS windows) used to be run as a batch job. That created problems for distributed systems with a single generic batch queue. Now the IDI server is spawned as a separate process (which also speeds up execution).

4. Change of MIDAS Release Cycle

The release cycle of MIDAS has been modified to ensure greater stability and reliability in the future. The internal development version of MIDAS (i.e. new) is frozen every second month. The last frozen version before a release will be tested both internally and at a number of external beta-test sites. The actual

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, the Federal Republic of 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) has recently become operational and a giant telescope (VLT = Very Large Telescope), consisting of four 8-m telescopes (equivalent aperture = 16 m) is under construction. 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, FRG. 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.

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MIDAS release will be based on this frozen version correcting major problems found during the beta-tests. This procedure is expected to give several advantages, namely: (a) installation procedures will be checked independently thereby making it possible to clarify the documentation, (b) problems in special applications can be reported in the release notes and help files, and (c) updates of the MIDAS Users Guide can be collated earlier and made available much closer to the actual release data than is now possible.

5. IEEE Floating Point Format in FITS

The original FITS agreement specified 8-, 16- and 32-bit integers as the only data formats. All integer formats are limited by an absolute error, whereas floating point formats can span a much wider numeric range with only a relative error. With the increased dynamic range of astronomical data, most image processing systems now process data in floating point format. To avoid time consuming conversions to and from integers and possible loss of accuracy, the FITS committee proposed the inclusion of the IEEE-754 32- and 64-bit floating point formats in the allowed FITS data types. This proposal was accepted as a standard by the IAU FITS Working Group after a formal vote in December 1989. Thus, the use of IEEE floating point numbers in the FITS data matrix is valid as of January 1, 1990.

The MIDAS intape/outtape commands have been upgraded to accept IEEE floating point data in FITS files (available from the 90 MAY release). Since it will take some time before all FITS readers in the community are updated, MIDAS will still default to write FITS tapes in the original integer format until the 90 NOV release.

6. MIDAS Hot-Line Service

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

- EARN: MIDAS@DGAESO51
- SPAN: ESOMC1::MIDAS
- Tlx.: 528 282 22 eso d, attn.: MIDAS HOT-LINE
- Tel.: +49-89-32006-456

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

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