No. 24 – June 1981

The Inauguration of the ESO Headquarters Building at Garching

The European Southern Observatory was formally founded on 5 October 1962 when the Convention was signed by Belgium, France, Germany, the Netherlands and Sweden, soon to be followed by Denmark. For many years, ESO was located partly in Geneva and partly in Hamburg. This split of the organization made the management difficult. About five years ago, the German government offered to construct a building for ESO on the campus of the Max-Planck Society at Garching near Munich. The administration immediately moved from Hamburg into provisional offices at Garching and about six months ago, after completion of the new building, the European centre of ESO found its final home.

The great variety of facilities which had to be incorporated into this one building confronted the architects, Hermann

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Dr. F. J. Strauss giving his address during the inauguration ceremony.

The First Steps of the European Organization

Charles Fehrenbach

Prof. Charles Fehrenbach, Member of the French Academy of Sciences and Director of the Haute-Provence Observatory, has been involved since the beginning with the genesis of ESO. He has been kind enough to write a short history of these early developments which are probably unknown to all the young European astronomers now using the ESO facilities and to many of the less young ones.

At the time when Italy and Switzerland are going to join the ESO astronomical community, it is interesting to relate the history of the beginnings of our organization.

It will be mainly anecdotal for the exact history is well recounted in the ESO bulletins and in an article by J. Oort published in the ICSU journal (vol. 3, pp. 30–35).

I was happy to be a party to all the first meetings, except for one or two preliminary ones, as a deputy to A. Danjon who I later replaced in the Council. I was chairman of the Instrumentation Committee for more than ten years. So I am well acquainted with these beginnings.

The idea of building a European observatory in the southern hemisphere was proposed by J. Oort and W. Baade as early as 1953 and they were able to convince P. Bourgeois, A. Danjon, O. Heckmann and B. Lindblad to share this idea.

The first informal meetings were also attended by A. Blaauw and, for a while, by the Astronomer Royal, Sir H. Spencer Jones, and by S. H. Bannier, Director of the Dutch Scientific Research Organization and his Swedish colleague, Dr. G. W. Funke.

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The Inauguration of the ESO Headquarters Building at Garching

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Fehling and Daniel Gogel from Berlin, with a complexity of problems. The most important elements were:

- Work-rooms for about 40 scientists
- Various data processing installations
- A library
- Photographic laboratories
- Laboratories for the development of telescopes and instruments
- Offices for the administration section

It was of course thought desirable that all areas should have their individual identity, where specialists could work undisturbed. On the other hand, however, close collaboration between the various disciplines was considered fundamental.

The architects brief was to build a scientific centre, their aim was to make it "habitable". They had to contend with the flat expanse of fields around Garching, the incomprehensible arbitrariness of the "nuclear-egg" neighbourhood, and their own creation – the Max-Planck Institute for Astrophysics – which was already under way when they received the commission for the ESO building. Today this building, of a very unusual appearance, reflects the architects' conviction, namely that of carrying through the concept from the interior rather than clinging to the image of a house.

The design is extremely successful. A short period of familiarization was needed during which everybody lost their way during a few hours or a few days in what, at first sight, looks like a labyrinth of the kind used to test the intelligence of rats. But human beings are on average cleverer than rats and the problem is quickly solved; after a while it appears that everybody found the building to be very convenient and a pleasant place to work in.

On Tuesday, 5 May 1981, the inauguration of the new headquarters took place in the presence of the President of the Federal Republic of Germany, Karl Carstens. The ceremony was attended by more than 200 invited guests, diplomatic representatives, administrators and scientists of the ESO and other countries, including Italy and Switzerland which are expected to join the organization within a few months.

In his welcoming address, the Director-General, Prof. L. Woltjer, stressed that one of the main aims of ESO was to promote cooperation in astronomical research. He expressed the feeling that, although important results have been achieved in this respect, more can be done.

Prof. R. Lüst, President of the Max-Planck-Gesellschaft, exposed his satisfaction in seeing ESO located in the immediate neighbourhood of the three Max-Planck Institutes at Garching, the Institute for Astrophysics, the Institute for

The new ESO headquarters building at Garching. Note that this picture was not taken on the day of the inauguration, but earlier in the winter.

The President of the Federal Republic of Germany, K. Carstens, is greeted on his arrival at the ESO building by Profs. L. Woltjer, R. Lüst and J.-F. Denisse.

Extraterrestrial Physics and the Institute for Plasmaphysics, all of which are devoted at least partly to Astrophysics. He thought that this proximity would be beneficial to all of them.

E. Stahl, Parliamentary Secretary of State with the Federal Minister for Research and Technology, expressed his satisfaction with this example of a successful European cooperation and his hope that also Austria would join the organization.

Dr. F. J. Strauss, Prime Minister of the Free State of Bavaria, voiced his contentment to see such a research centre as ESO near Munich, which has always been a cultural centre. He said that, in his opinion, the economical survival of the European countries which are lacking raw materials and energy sources has to be based on creativity and on intellectual effort.

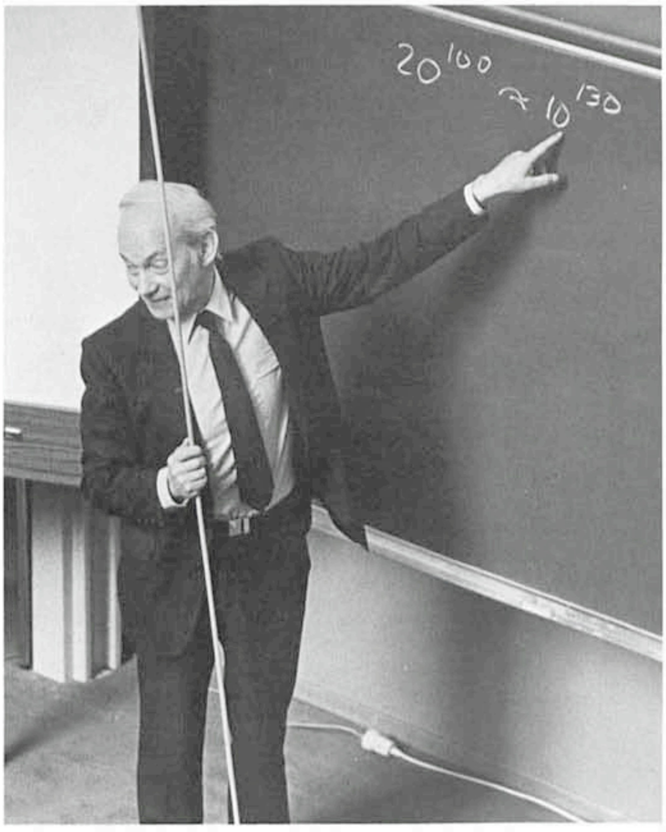
Prof. J.-F. Denisse, President of the ESO Council, briefly related the history of ESO, and said that this venture is now a success and that this is due for a large part to the excellent and energetic management of the present Director-General. He added that this success would be more complete if Great Britain was joining ESO, but this possibility in his opinion is unfortunately small.

After the opening ceremony, a lunch was offered by the President of the Federal Republic of Germany, during which he delivered an address; he welcomed ESO, its collaborators and their families to Germany, the host country. He was thanked by Prof. Denisse.

In the evening, a reception was offered by the Bavarian State Government to participants and their spouses.

The afternoon and the following day were devoted to a symposium on the "Evolution of the Universe". The six talks are listed below:

- "Space Sciences and Geosciences: Evolution of Two Interactive Fields of Knowledge" by Prof. H. Curien, President of the French Centre National d'Etudes Spatiales.
- "The Evolution of the Solar System" by Prof. H. Alfven, Nobel Prize in Physics (1970).
- "The Early Evolution of Life on Earth" by Prof. M. Eigen, Nobel Prize in Chemistry (1967), Director of the Max-Planck Institute for Biophysical Chemistry in Göttingen.
- "Particle Physics in the Early Universe" by Prof. L. van Hove, former Research Director-General at CERN.
- "The Evolution of Large-Scale Structures in the Universe" by Prof. J. H. Oort, former Director of the Leiden Observatory.
- "Evolutionary Aspects of the Cosmic Black Body Radiation" by Dr. D. W. Sciama, Fellow of All Souls College in Oxford.



Prof. M. Eigen during his talk.

The remarkable talk by Prof. M. Eigen opened new windows on a field quite unfamiliar to most of the audience.

In spite of the extremely bad weather experienced on the first day, all participants were pleased with the perfection of the organization of these events, and left Munich with the feeling that ESO is now a grown-up and efficient organization.

P. V.

The First Steps of the European Organization

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These preliminary and very informal meetings lasted for seven years for, if agreement among the astronomers was immediate, that of the government authorities was difficult to get. In France, for instance, a vote by the Parliament was necessary. Such commitments were essential to ensure proper subsequent support and financing. Some of the arguments were trifling and were the cause of long delays: everybody agreed on the principle of sharing the expenses and on the aims of the observatory, but it was impossible to reach an agreement on one expression, "le coût des facteurs", which the French authorities rejected as being incomprehensible but which the others did not want to change . . .

Nevertheless, the definitive convention was signed in Paris on October 5, 1962, by five countries: Belgium, France, Germany, the Netherlands and Sweden. The Ford foundation had promised and indeed paid on September 21, 1964, a grant of one million dollars. Denmark joined only later, but attended, as an observer, a number of meetings.

But, these seven years were not lost.

First, the choice of a site occupied a number of young European astronomers in South Africa where the search zone was located, between latitudes –26° and –34°, from Johannesburg to Capetown. This zone was quickly restricted to the region of Great Karoo and west of it. If I recall now these campaigns of site searching, I am struck by our lack of knowledge on the conditions required for good seeing, for, if meteorological statistics gave accurate information on the number of hours of clear sky, our ideas on atmospheric turbulence were very rudimentary. We tried to measure or to estimate the seeing on the Karoo plateau. But we were not aware that good images were associated with small diurnal atmospheric temperature variations which are found above the inversion layer at about 2000 to 2400 meters elevation. Such a small thermal variation is moreover essential for the smooth working of a large telescope.

In my opinion, this fact excluded all the sites we studied in South Africa, including the one supported by the French group in Zeekoegat. It would however be dishonest to say that there were no other reasons for forsaking South Africa.

During these bad years (1953–1960), the United Kingdom definitely withdrew from this project and the French authorities did not feel themselves to be very much involved. The French delegation was not any more authorized to participate, but the astronomers did not want to give up the project and they thought of building a French station for studying the Magellanic Clouds, the operation of which would be in the framework of ESO. A. Danjon got the funds enabling the Marseille Observatory to build a 40 cm objective prism telescope, its dome and its auxiliaries. The travel expenses and the per diem were paid by ESO for testing the Zeekoegat station where French astronomers built and used this instrument from 1958 to 1966. I cannot cite the names of all the pioneers who lived there in quite difficult conditions, and of the resident astronomers who subsequently enjoyed much better conditions. I wish to thank here all of them, for it is thanks to them that the project was not given up.

Our radial velocity measurement staff brought back from all these stays several lasting impressions: the beauty of the country, the enthusiastic and always kind welcome from the population, but also an uneasy feeling in spite of our excellent relationship with all the ethnic groups, but we did not have to form an opinion on this problem.

How many pleasant recollections: like the edict that I had to issue to limit the proliferation of donkeys on our station, our South African employees measuring their standard of living by the number of their donkeys!

From the astronomical point of view, we made good observations, but thermal variations were strongly disturbing, particularly as the large ESO 40 cm Objective Prism seems to be more sensitive to temperature changes than that of the Haute-Provence Observatory.

These searches for a site did not reach a conclusion, but by a dramatic turn, our American colleagues form AURA had decided to build an observatory in Chile and they had studied a site near La Serena (Tololo) and, according to their investigations, it was much better than our African sites.

Professor O. Heckmann, who was the director of the organization as well as being in charge of the Hamburg Observatory, paid a visit, together with J. Rösch, to our American colleagues in Chile and came back so strongly convinced that the Council sent, in June 1963, a few Council members to study the problem on the spot. I was amongst them. We first visited, on horseback, the American site at Tololo. Our colleagues offered us an adjoining site at Morado, but we preferred to have our own site to preserve our independence. After a survey of the maps to identify the land belonging to the State of Chile and an exploration with a helicopter of the Chilean army, we chose an area 100 km north of La Serena. After two or three days on horseback, we picked out a summit which was called Cinchado; however, because this name was widespread, O. Heckmann suggested instead the name La Silla (the saddle) which has been adopted.

O. Heckmann signed a convention with the Chilean government in November 1963 which displeased some of our diplomats who, however, adopted this very advantageous convention. The Council finally decided the installation on La Silla in 1964.

The site began to be investigated in 1963, especially by A. B. Muller who devoted all of his time to Chile.

The buying of a guest-house in Santiago, at a very favourable time, is of great help and considerably facilitates the transit from Europe to La Silla. If our American colleagues sometimes call it the "Petit Trianon", it is perhaps because they envy our luck!

During this time, the preparation of the observing instruments, telescopes and accessories was undertaken by Professor O. Heckmann, assisted by Professor J. M. Ramberg and by an Instrumentation Committee of which I was the chairman for more than ten years.

In order to quickly give an effective scientific life to the observatory, it was decided to build three telescopes of intermediate size; the conception and building of a Schmidt telescope were entrusted to Germany. We chose the same focal length as that of the Palomar Schmidt, 3.05 m, but a diameter of 1 m for the corrector to provide good images over the whole spectral range from 330 to 700 nm. The construction of the optics, mirror and corrector, as well as the mechanical building were much delayed and the corrector, achromatized for too large a wavelength, is not excellent in the ultraviolet. A number of small difficulties delayed the commissioning of this large southern Schmidt telescope.

The 1.52 m telescope was originally a copy of the Haute-Provence Observatory telescope and should have had only a coudé focus. At the last minute, it was decided to change the initial plan by making a hole in the mirror and installing also a Cassegrain focus.

The building of a photometric 1 m telescope was also decided as well as the transfer to La Silla of the Large Objective Prism telescope installed in South Africa.

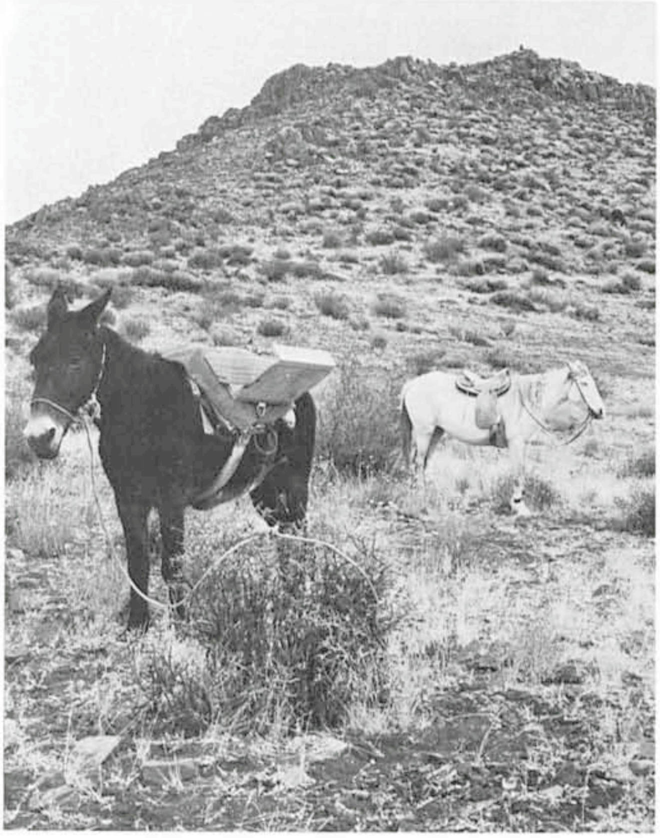
The conception of the large telescope met many difficulties. The convention had planned a 3 m telescope. A study trip by some of us to the Lick Observatory, however, showed that the building of an observing cage in a tube of such a diameter was difficult and the astronomers succeeded in convincing the whole Council of the need to increase the telescope diameter to 3.5 m.

The choice of the optical parameters and then that of the support system of the main mirror caused a number of difficulties. In the French astronomical community, there was some opposition for reasons more sentimental than real, to the Ritchey-Chretien system (how difficult it is to be a prophet in your own country! . . .) and to a mirror with a f/3 aperture.

Nevertheless, a final agreement was reached on all the points and especially on the mirror support, at least partially thanks to important meetings organized under the auspices of the IAU on large telescopes and mirror support systems.

In the mean time, it had become possible to obtain a 3.6 m blank of fused silica; a thickness of 50 cm was chosen (in spite of A. Couder's idea of making a thinner mirror). This blank weighs more than 12 tons.

Negotiations were started with the only two American suppliers able to deliver such a blank, and the Corning Corporation was chosen.



The only available transportation to reach La Silla in 1963.

The melting and cutting of this huge mirror did not proceed without difficulty – the first melting was defective for the blank, made of polygonal prisms melted together, was covered with a single bubbleless layer. This had subsided during melting and, at the first cutting, the concavity of the mirror entered into the internal layer and the blank, accepted with reserves, had to be sent back to the United States. The upper layer was cut out and replaced by a new one.

But we were dogged by ill luck as, during heating, one of the protecting silica bricks was, by mistake, replaced by a glass brick and the blank, when it came out of the oven, had a hole of about 10 cm. Thanks to the know-how of REOSC and especially of its director, A. Bayle, it was possible to cut out a hemisphere at the location of the hole and to fill it, with optical contact, with a silica hemisphere.

Cutting this mirror posed another problem. None of the European manufacturers was equipped for figuring a mirror of the size and we seriously thought of installing an optical laboratory in France.

The contacts we had with European companies lead to the signing of a contract with REOSC, a French company in Paris. The Instrumentation Committee was sometimes blamed for having defined insufficient image quality specifications, but the contract made provision for an additional clause for improving the figure of the mirror if that turned out to be necessary. The collaboration between the German (H. Köhler, G. Schwesinger) and the French (A. Couder, A. Baranne) opticians was very fruitful and the final quality of the mirror was such that all reserves, often ill considered, were forgotten.

The choice for the type of mounting was, after many discussions, of an intermediate type between a cradle mounting and a fork mounting. The design of this system was entrusted to an excellent German engineer, W. Strewinsky, but almost without any project office and without signature of a formal contract.

La Silla, October 1966 . . .

. . . and La Silla today.

The main weakness of our organization then appeared very clearly: the absence of a project office with engineers and technicians devoting all of their time to the study of the instruments, the preparation of the demands for tender, the choice of the manufacturers and the supervision of the work.

A small group of astronomers and a few administration staff were very busy during the creation of the organization.

The Instrumentation Committee tried in vain to act as a project office but it had neither the means, nor the abilities to do so, in spite of all the individual willingness.

The creation of a project office was then envisaged, but it was already late; fortunately, at the initiative of the French delegation and especially of Mr. M. Alline, representative of the French Ministry of Foreign Affairs, contacts were established with the CERN Director-General, then the late Professor B. Gregory. They led to the creation of a project office for the organization, located in Geneva and strongly supported by the large CERN design departments.

There is no doubt in my mind that it was the installation in Geneva which saved our organization. The efforts of the successive Directors-General, Professors O. Heckmann, A. Blaauw and L. Woltjer, who devoted all their time to ESO, were of course essential.

The initial project for the large telescope was completely revised by this project office, under the direction of S. Laustsen. We should not, however, forget the role of other colleagues, especially of J. M. Ramberg.

The large telescope suffered serious delays, due partially to this lack of a project office, but also to the scattering of the services: in Europe, Hamburg and Geneva, without mentioning the small Marseille group; in Chile, Santiago, La Serena and also La Silla!

This was ungovernable, in spite of all the willingness of the Director in Hamburg and Geneva and of B. Westerlund in Chile.

Particularly, the three centres in Chile were the cause of endless travelling by the personnel from the mountain to La Serena and to Santiago.

For a time, evil tongues were saying that Astronomy was an alibi for the administration.

These circumstances are now out of date. La Silla is the heart of our organization – the transfer from Geneva to Munich, regretted by some, including myself, will certainly be beneficial.

This article has been originally written in French; the editor takes full responsibility for the poor translation.

FAINT OBJECT CAMERA BOOKLET

"The Faint Object Camera for the Space Telescope" booklet is now available to qualified scientists free of charge. This booklet describes the technical and operational characteristics of the FOC which is the European contribution to the instrument complement on the Space Telescope. In addition, the booklet describes various possible scientific programmes which should be feasible with the FOC. Interested persons should write to ESA at the following address:

ESA Information Retrieval Service
8–10, rue Mario-Nikis
F-75738 PARIS
France

P. C.

The Helium Content and Evolution of Subdwarf O Stars

K. Hunger and R. P. Kudritzki, Institut für Theoretische Physik und Sternwarte, Kiel

Introduction

Subdwarf O stars are faint blue stars that have luminosities 3–8 magnitudes below the main sequence. In the Hertzsprung-Russell diagram they occupy a region intermediate between normal dwarfs and hot white dwarfs. Phenomenologically they appear as an extension of the horizontal branch towards very high temperatures ($T_{eff} > 35\,000$ K). The link between the two classes form the subdwarf B stars.

Characteristic for their spectrum, besides being blue, are the unusually broad absorption lines which belong to hydrogen and helium. A prominent line that is always present – otherwise it is no sdO star – is the line λ 4686 of ionized helium.

The spectral characteristics though pronounced in high dispersion are less conspicuous otherwise, which makes the detection of an O subdwarfs not an easy task. The largest number of O subdwarfs has been found in surveys of regions around the galactic poles, often by making use of objective prism plates. So far some 100 such stars are known, and it is anticipated that a complete survey would yield a much larger number. With little exaggeration one may say that subdwarf O stars are a rather common feature in the sky and, if the life time of a star spent in this phase of evolution is not exceedingly long, that a substantial fraction of the stars will eventually pass through the sdO phase before they reach their final destiny, the white dwarf "cemetery". If so, then it means that sdO stars are in competition with central stars of planetary nebulae which are well known to form the main bulk of white dwarf progenitors.

To pin down the status of evolution, one has to have a good knowledge of the basic stellar parameters like effective temperature, gravity, and luminosity, two of which mark the location in the Hertzsprung-Russell diagram. This enables one (hopefully) to find a suitable evolutionary track that passes through the sdO domain and which may shed light on the past and future evolution. Further clues may come from the abundances of chemical elements, like the helium/hydrogen ratio and the nucleogenetically important elements C, N and O. In order to collect these data for a meaningful sample, a campaign was started in Kiel to analyse all available sdO spectra.

Spectral Analysis

There are two problems one faces when one wants to analyse spectra of sdO stars: first, they are faint. Except for a few bright stars, they are fainter than 12 mag, which makes the use of a big telescope unavoidable. Second, they are hot. Simple methods of analysis – those which are based on the local thermodynamic equilibrium (LTE) – fail because the intense radiation field upsets the atomic level populations which are otherwise in a Boltzmann equilibrium. An absorption line may appear strong not because the chemical element in question is abundant, but because the lower atomic level is overpopulated by radiative processes. Non-LTE effects (NLTE) may lead to distorted line profiles, and moreover, the entire structure of the atmosphere may be affected.

Even in the case of high gravity stars like subluminous O stars, the use of classical LTE methods yields gravities and hence masses which are too large by a factor of 5! The older analyses were suffering from the lack of adequate NLTE model atmospheres. The most complete analysis of subdwarf O stars is contained in the pioneering paper of Greenstein and Sargent (1974). Besides the problems with gravity and effective temperature, the helium to hydrogen ratio remains undetermined altogether in this analysis.

In the meantime, an extensive grid of NLTE model atmospheres for subluminous O stars became available (Kudritzki, 1976) plus the relevant line formation calculations (Simon, 1979). As a pilot project, three of the brightest O subdwarfs were analysed in detail, HD 49798 (Kudritzki and Simon, 1978, Simon et al. 1979), HD 127493 (Simon, 1979 and 1981) and BD + 75°325 (Kudritzki et al., 1980). For the first two objects, 20 Å/mm spectrograms have been obtained with the ESO 1.5 m telescope. In addition, a number of IUE high resolution spectrograms were secured. An elaborate scheme has been developed how to adapt a model atmosphere in order to reproduce the observed profiles of the Balmer-, He I and He II lines and also the spectral distribution of the continuum. The success of the method is demonstrated in Fig. 1 where for the close binary HD 49798 the observed and computed profiles of one line each of H I, He I and He II are compared. The profiles have been computed for the finally adapted model with T_{eff} = 47500 K, log g = 4.25 and the helium number fraction y = 50 %. The model describes equally well the "optical" and the UV spectrum, as can be seen from Fig. 2, where the He II lines in the UV are compared with high resolution IUE observations.

From the experience gained with high dispersion spectrograms it was concluded that if one restricts the analysis to the basic stellar parameters, T_{eff}, log g and the helium abundance, then medium resolution spectrograms would be of sufficient quality to obtain reasonable answers. It means that (partial) analyses of subluminous O stars could be extended to much fainter objects by making use of the 3.6 m telescope, the Boller and Chivens spectrograph in the dispersion range of 30–60

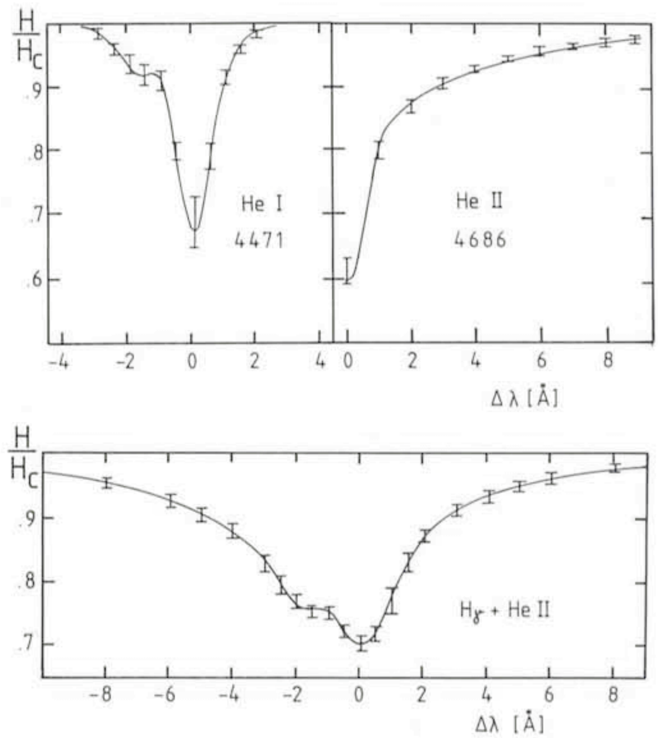


Fig. 1: *Observed profiles (with error bars) of visual hydrogen and helium lines of the sdO star HD 49798 compared with theory (flux in units of the continuum).*

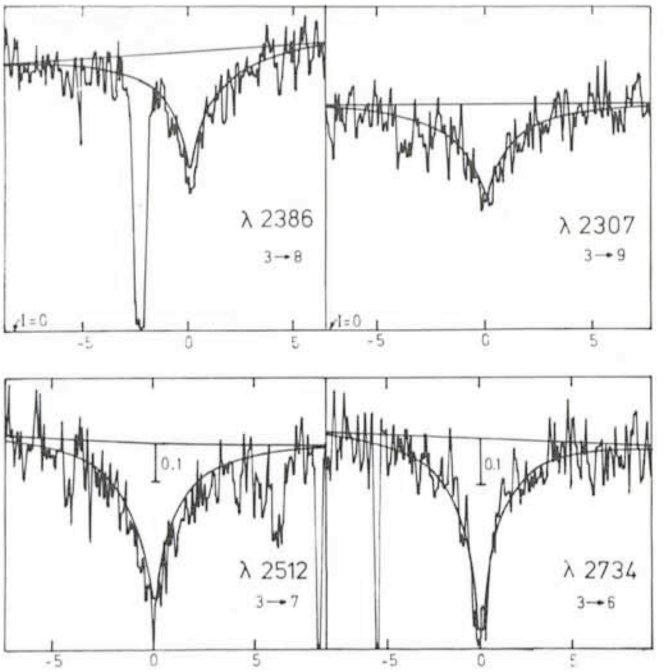


Fig. 2: *High resolution IUE observations of HD 49798: Observed profiles of He II lines compared with theory (the sharp saturated lines are of interstellar origin).*

Å/mm and the IDS. Meanwhile a larger number of objects has been observed by us.

The IDS Spectrograms

As an example, three of the 29 Å/mm IDS spectra are shown in Fig. 3. Immediately evident is the large variety that sdO spectra present. SB 884 (middle) shows the typical broad lines due to Hγ, He I and He II. In the upper tracing, Hγ is missing, which means that SB 21 is an extreme hydrogen-deficient star,

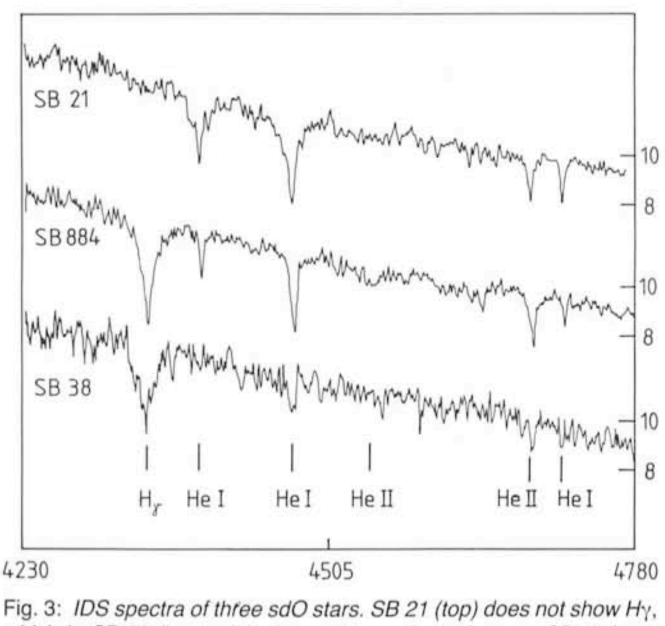


Fig. 3: *IDS spectra of three sdO stars. SB 21 (top) does not show Hγ, which in SB 38 (bottom) is the most prominent feature. SB 21 is an extreme helium star, while SB 38 is helium poor. SB 884 has roughly a normal amount of hydrogen and helium.*

while the bottom star, SB 38, is almost the opposite, a helium-deficient star.

Quantitative results are obtained by means of fit diagrams in the (log g, log T_{eff})plane (Fig. 4) where the loci are plotted along which observed and computed equivalent widths agree for the indicated lines. The intersection of the various lines yields the atmospheric parameters, T_{eff} and g. The minimum scatter defines the number fraction of helium. A final check is made by comparing line profiles (Fig. 5) which proves that even IDS profiles (or the theory) can be trusted.

Before we describe the results, let uns briefly comment on the (g, T_{eff}) diagram because the evolution will be discussed on hand of this diagram.

(g, T_{eff}) Diagram

The above described spectral analysis automatically yields effective temperature T_{eff} and gravity g, besides the helium abundance. Stellar interior calculations also provide T_{eff} and g. Therefore, it is wise to discuss g and T_{eff} directly, rather than to make a poor guess of the distance and thereafter discuss the conventional H.R. diagram. The (g, T_{eff}) diagram is, morphologically spoken, a H.R. diagram containing the same information as the latter. The hydrogen main sequence transforms into a horizontal line, as g is nearly constant on the main sequence. A track with constant luminosity runs as

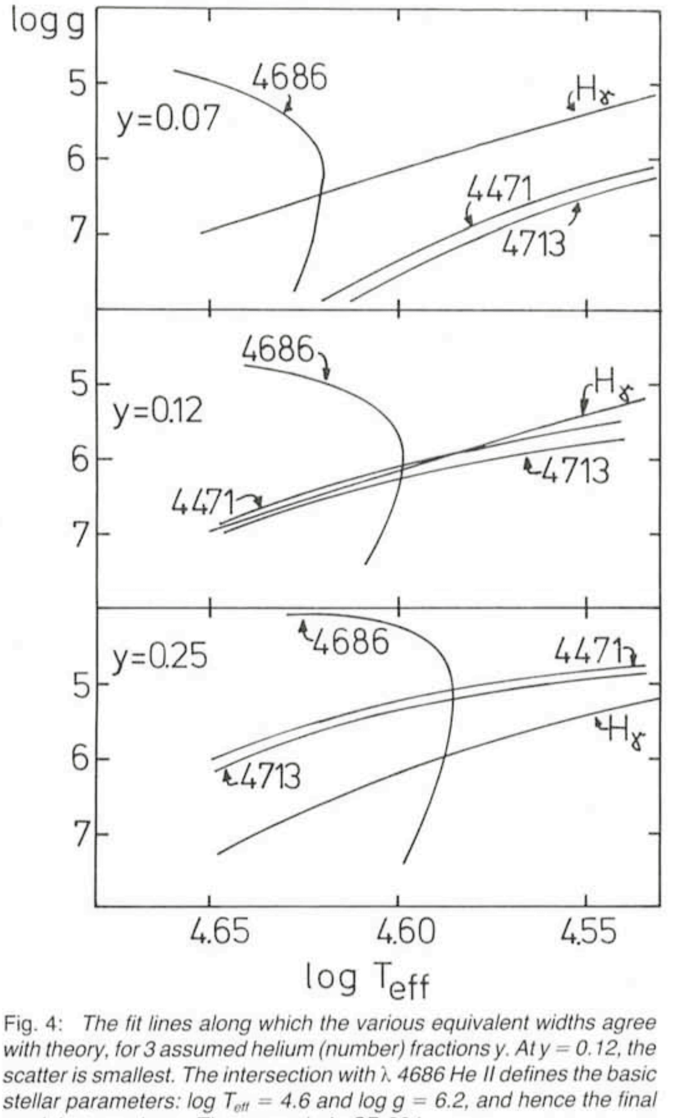


Fig. 4: *The fit lines along which the various equivalent widths agree with theory, for 3 assumed helium (number) fractions y. At y = 0.12, the scatter is smallest. The intersection with λ 4686 He II defines the basic stellar parameters: log T_{eff} = 4.6 and log g = 6.2, and hence the final model atmosphere. The example is SB 884.*

straight line from the upper r.h. corner to the lower l.h. corner. Giants are found at the upper part of the diagram, dwarfs at the lower part, etc. Late phases of stellar evolution proceed mostly at constant luminosity i.e. on tracks which run more or less parallel to the above described straight line.

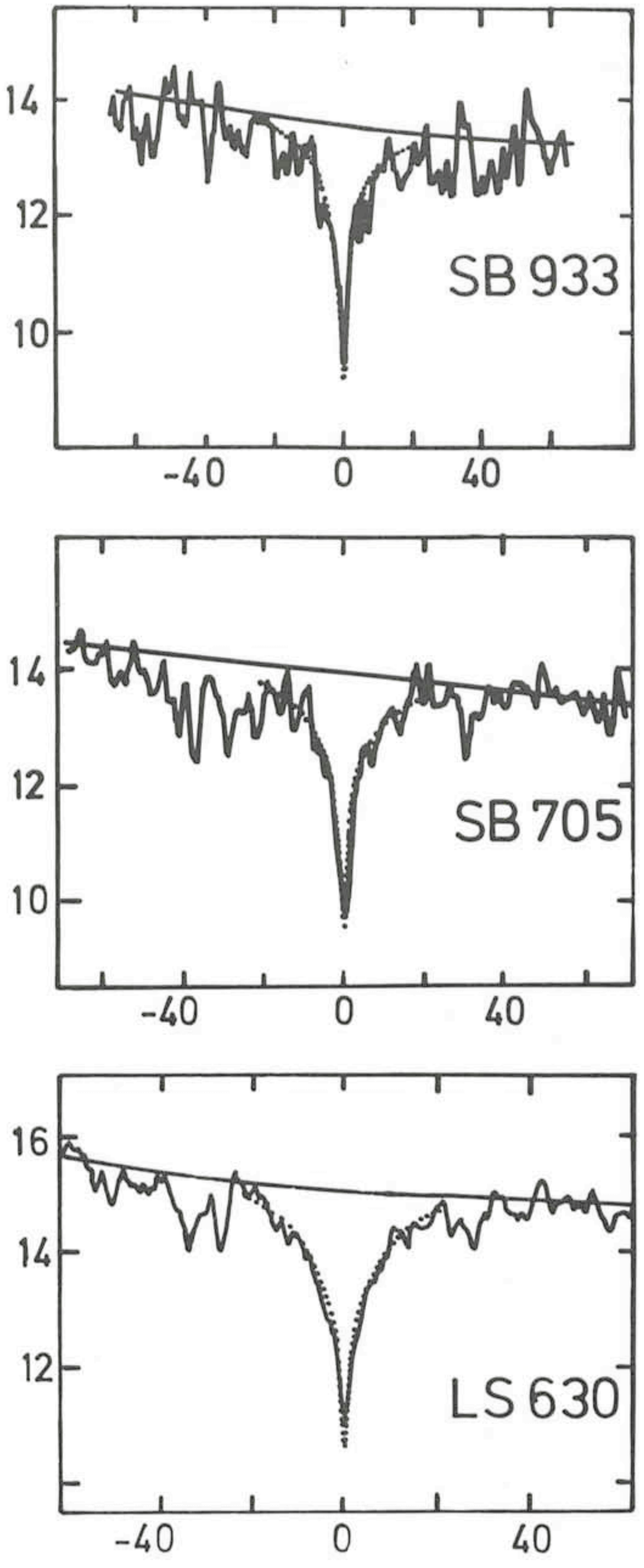


Fig. 5: *From the finally adapted model atmospheres (see Fig. 4), profiles are computed (dotted) and compared with observation, to check the validity of the model atmospheres. The example is λ 4686 of He II.*

The Helium Content

The relevant portion of the (g, T_{eff})diagram is shown in Fig. 6. The observed sdO stars are marked by symbols which shall indicate if the star consists of helium only (filled circles), if it is a mixture of equal numbers of helium and hydrogen (half filled circle), or if it is helium poor (open circle). Please note that these abundances refer only to the photosphere and that the interior probably contains carbon and oxygen. It is striking that there exists a sharp boundary between helium rich and helium poor, the critical temperature being 40,000 K. The helium poor sdO stars are better called sdOB stars because they appear as intermediate between the SdB stars which are also known to be helium deficient and the SdO's.

It is hard to conceive of a stellar evolution that could lead to a subdivision with respect to helium. Moreover, the SdOB stars have a helium content of as little as 1 – 2 %, which is far below the primordial helium abundance. The answer to this is diffusion. All sdO's plus sdOB's are helium enriched presumably, the strong gravity however dragging the heavier helium ion below the photosphere, whenever $T_{eff} > 40{,}000$ K. The prerequisite for gravitational settling is an atmosphere that is quiet. Mass loss – which is being observed in some low gravity subdwarf O stars – and convective instability might work against diffusion. In fact, for temperatures just above 40,000 K, a helium convection zone occurs, which is too weak, though, to upset the radiative atmosphere, but which may nevertheless impede diffusion.

The Supernova Remnant SN 1006 and the Binary LB 3459

In Fig. 6 the location of the recently identified blue star near the center of a supernova is also shown. Amazingly, it turns out to be a typical sdOB star of which so far only five are known.

If it is really the remnant of a star that exploded in A.D. 1006, and which presumably lost its hydrogen rich atmosphere, why is it not helium rich or even metal rich? The answer again may be diffusion. The time scales for diffusion are rather short for these high gravity objects and probably less than the time which elapsed since the supernova exploded.

Another interesting object shown in Fig. 6 is the close binary LB 3459. It consists of a primary with $0.5_{\odot}$ (LB 3459) and a secondary with 0.07 $M_{\odot}$ (Kilkenny et al., 1979, Kudritzki et al., 1981). If mass transfer and mass loss have produced this strange system then one should expect a helium rich rather than a helium poor object. The fact that LB 3459 appears as sdOB star with helium down to 0.1 % again points to diffusion as the "demixing" agent.

What then means the helium content of a subluminous star? If it were a characteristic for the outer shell then it could serve as an indicator for the evolution of the star in question. But now it appears as if, for these objects, the helium content merely describes the momentary state of the atmospheres, more or less independent of the past history; the interplay of mass loss, gravitational settling and convective instability probably being the determining factors.

The Evolution

Among the sdO's there are some binaries. Their evolution can be understood as a result of mass transfer. The majority, however, appears single. How can they have enriched helium?

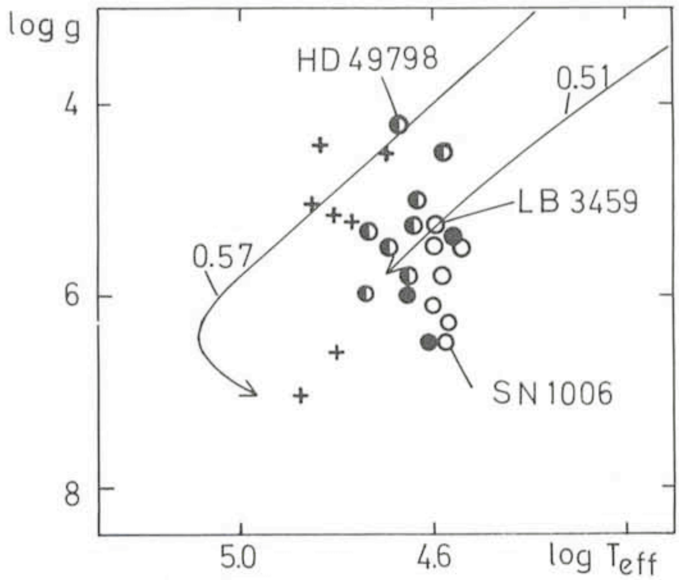


Fig. 6: *The (g, T_{eff}) diagram of subdwarf O stars, the equivalent to the conventional Hertzsprung-Russel diagram. The helium poor sd OB stars are marked by open circles. The supernova remnant suspect SN 1006 as well as the close binary star LB 3459 are also sd OB's. The extremely helium rich objects have full circles, while the intermediate helium rich have half filled circles. Crosses denote the locations of 7 recently analysed central stars of planetary nebulae. The evolutionary tracks belong to stars with 0.51 and 0.57 solar masses (Sweigert et al., Schönberner) that evolve from the horizontal branch to the white dwarfs.*

A further problem arises from the mass. For some sdO's fairly reliable distances exist and hence luminosities. From the effective temperature and gravity, the mass can be derived. For single sdO's the mass turns out to be 0.5 $M_\odot$. How can a star with that little mass have evolved, without having experienced a substantial mass loss?

The scenario may be the following: stars with masses of more than say 1.2 $M_\odot$ lose mass at the top of the first giant branch, at a rate which in some cases may be much stronger than the usually accepted wind – possibly through the helium flash which, after all, is not as harmless as one thinks? After mass ejection the stars are found on the horizontal branch: some with little mass left ($\sim$ 0.5 $M_\odot$), on the blue side – these are the helium rich stars – and some with larger masses ($\sim$ 0.8 $M_\odot$), on the red side – they have normal photospheric composition. The red HB stars have enough mass left in their outer shell to climb up a second time the (now asymptotic) giant branch, at the top of which they expel a shell, the planetary nebula. The evolution is described in Fig. 6 (Schönberner, 1979). The track with 0.57 $M_\odot$ beautifully matches the position of 6 recently analysed central stars of planetary nebulae – these are the first direct spectral analyses, without recourse to the Zanstra method (Méndez et al., 1981, Kudritzki et al., 1981). The majority of white dwarfs also have 0.57 $M_\odot$. The blue helium rich stars have too little mass left in their shell. They do not reach the asymptotic giant branch and hence are not capable of ejecting a shell. They reach the position of the sdO's on a track which is sketched according to Sweigart et al. (1974). They are likely to form the low mass component of white dwarfs.

If this scenario is correct, then the switch, whether planetary nebula or subdwarf O star, is turned at the top of the first giant branch.

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List of Preprints Published at ESO Scientific Group

March–May 1981

139. T. R. Geballe, W. Wamsteker, A. C. Danks, J. H. Lacy and S. C. Beck: Infrared Line and Continuum Views of G333.6-0.2. *Astrophysical Journal,* Main Jornal. March 1981.
140. N. Vogt, H. S. Geisse and S. Rojas: Up-to-Date UBVRI Values for the E-Region Standard Stars. *Astronomy and Astrophysics,* Supplement Series. March 1981.
141. R. M. West and H. G. Walter: Optical Positions of Benchmark Radio Sources South of +5° Declination. *Astronomy and Astrophysics,* Supplement Series. March 1981.
142. R. M. West, J. Surdej, H. E. Schuster, A. B. Muller, S. Laustsen and T. M. Borchkhadze: Spectroscopic and Photometric Observations of Galaxies from the ESO/Uppsala List. *Astronomy and Astrophysics,* Supplement Series. March 1981.
143. S. D'Odorico and M. Rosa: Wolf-Rayet Stars in the Giant H II Region NGC 604. *Astrophysical Journal.* March 1981.
144. I. S. Glass: The Infrared Continua of Active Galaxies. *Monthly Notices of the Royal Astronomical Society.* March 1981.
145. A. Danks and G. Alcaíno: Interactions in Two Contrasting Examples of Galactic Groups. *Astronomy and Astrophysics,* Main Journal. March 1981.
146. M. Dennefeld and D. Kunth: Supernova Remnants and H II Regions in M 31. *Astronomical Journal.* March 1981.
147. D. Alloin, M. G. Edmunds, P. O. Lindblad and B. E. J. Pagel: The Mild Abundance Gradient of NGC 1365. *Astronomy and Astrophysics,* Main Journal. May 1981.
148. A. F. M. Moorwood and P. Salinari: Infrared Objects Near to H_2O Masers in Regions of Active Star Formation. II. Survey and 1-20 μm Observations of Southern Sources. *Astronomy and Astrophysics.* May 1981.
149. G. Contopoulos: Inner Lindblad Resonance in Galaxies. Nonlinear Theory. IV. Self-consistent Bars. *Astronomy and Astrophysics,* Main Journal. May 1981.
150. P. A. Shaver, D. S. Retallack, W. Wamsteker and A. C. Danks: The Distance to G316.8-0.1. *Astronomy and Astrophysics,* Main Journal. May 1981.

Optical Searches of Gamma-ray Burst Locations

C. Chevalier and S. A. Ilovaisky, Observatoire de Meudon
K. Hurley, Centre d'Etude Spatiale des Rayonnements, Toulouse
Ch. Motch, ESO Garching

Introduction

First discovered in 1973, gamma-ray bursts are cosmic events of very short duration, some of them lasting only a few tenths of a second, whose origin has since been a puzzle. They are now being detected mainly in the hard X-ray range (100–500 keV) by omnidirectional scintillator detectors placed on board spacecraft located in different parts of the solar system (Venera 11 an 12, Pioneer Venus Orbiter, Helios 2, Prognoz 7, ISEE-3 and the Vela satellites).* When a burst is detected by at least 3 spacecraft, triangulation over interplanetary distances is possible through arrival-time analysis of the burst time-histories recorded by the different detectors. Observations by as many as 7 different probes now offer the possibility of unambiguously localizing gamma-ray bursts on the sky to arc-minutes, and sometimes to tens of arc-seconds.

Small error boxes have recently been derived for three southern hemisphere bursts. The 1978 November 19 event is localized in a 5 by 1.5 arcmin high galactic latitude ($\alpha = 1^h16^m$, $\delta = -28°53'$; $b^{II} = -84°$) box which contains two weak radio sources (one is polarized), a very weak X-ray source found by the Einstein satellite as well as several faint optical objects (Cline et al. 1980). In Fig. 1 we show the time history of this event. The extremely intense 1979 March 5 event has now been localized in a very small box (~10 by 20 arcsec) which falls on the edge of the N49 supernova remnant in the Large Magellanic Cloud (Evans et al. 1980). Finally, the brief 1979 April 6 event has been localized in a high galactic latitude box ($\alpha = 23^h11^m$, $\delta = -49°55'$; $b^{II} = -61°$) of about 30 by 40 arcsec with no optical objects visible down to the limit of the SRC Schmidt Survey (22.5 mag). (Laros et al. 1981).

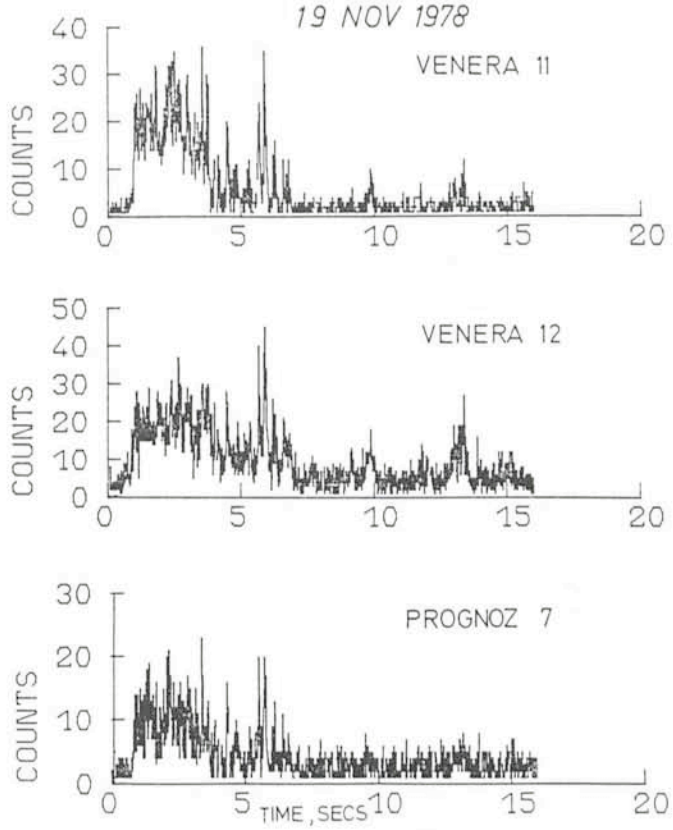

Fig. 1: *Time history of the 1978 November 19 gamma-ray burst event as observed by the Venera and Prognoz CESR detectors. The time resolution is 16 ms and the energy range from 100 keV to 2.5 MeV (from Chambon et al. 1980).*

Optical Observations

In an effort to single out any possible candidate objects which may be associated with the bursts, we have started an optical search programme in these and other boxes by means of photographic observations at the prime focus of the 3.6 m ESO telescope. In spite of the inevitable difficulties with the instrumentation, the weather and the shortage of observing time (!) we have begun to obtain preliminary results. A deep plate of the 1979 April 6 event location taken by H. E. Schuster in September 1980 with the triplet adaptor on pre-sensitized and unfiltered IIIa-J emulsion for 90 minutes has been scanned with the Nice Observatory PDS microphotometer and later analysed with the interactive image processing system at Meudon. The central region is shown in Figure 2, photographed off the COMTAL colour TV display, after smoothing and contrast-enhancing by removing the low density-value tail of the image histogram. The error box is shown as a polygon. We definitely see three objects in the box which are not visible in the J or B Schmidt films of the area. The limit of our plate is at least a full magnitude deeper than the SRC Survey, or about 23.5 to 24 magnitude.

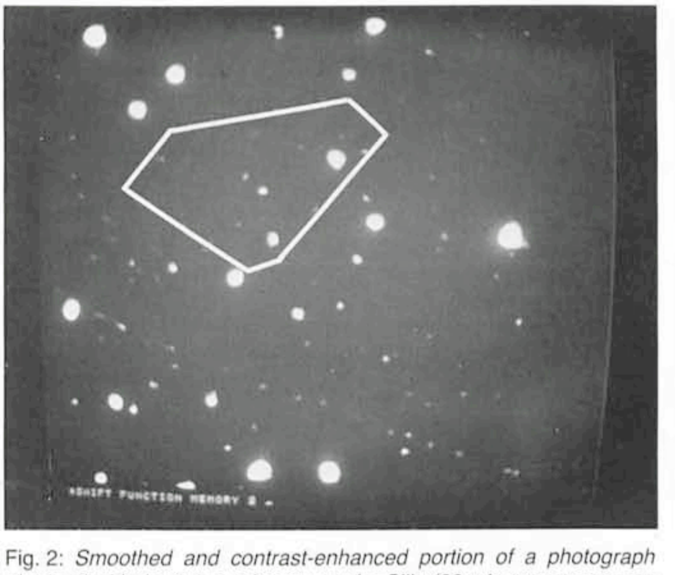

Fig. 2: *Smoothed and contrast-enhanced portion of a photograph obtained with the 3.6 m telescope at La Silla (90 min exposure on an unfiltered IIIa-J emulsion) at the location of the 1979 April 6 event. South is at the top and west to the right. The 30 by 40 arc s^{-1} error box is shown as a polygon. Note the three objects in the box.*

* The Venera probes and the Prognoz satellite carry detectors developped at CESR, Toulouse.

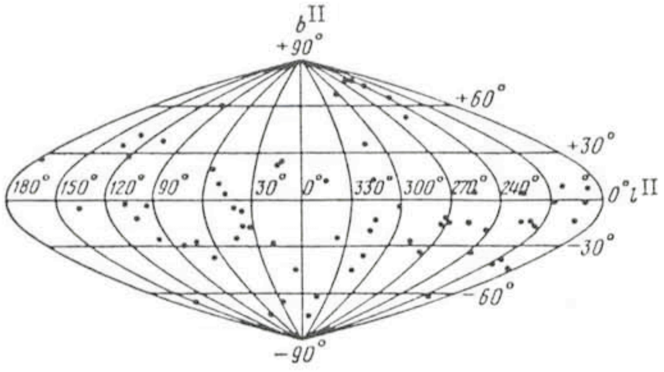

Fig. 3: *The positions of the 69 γ-ray burst sources now roughly localized, shown in galactic coordinates (from Mazets et. al. 1980).*

If we take into account the known surface densities of faint stars and galaxies at different magnitudes near the galactic pole reported, among others, by Tyson and Jarvis (1979) we find that there should be about 37,800 objects per square degree with magnitudes between 22 and 24. Therefore we would expect between 1 and 3 such objects (Poisson statistics!) in the 800 arcsec^2 box which would not appear in the Schmidt plates. Moreover, most of the faintest should be galaxies.

In an attempt to find if any of these faint objects are galactic stars, we plan, during the coming months, to obtain magnitudes, colours and image profiles by continuing photography at the 3.6 m prime focus and also by making electronographic (McMullan camera) and electronic (CCD camera) observations.

The Nature of the Bursts

The spatial distribution of the now about 70 roughly localized bursts is more or less isotropic (see Figure 3). This could indicate either a very local origin (nearby low-luminositiy optical objects) or an extragalactic origin (associated with faraway galaxies). The intensity-vs-number (so-called logN-logS) distribution (see Figure 4) may give some indication in favour of a local origin since, after following a $S^{-1.5}$ power law, it flattens out at low intensities much more than would be expected from instrumental selection effects alone.

The very short time scales sometimes exhibited by gamma-ray bursts (see Fig. 1) imply very compact sources like neutron stars (the rise time of the 1979 March 5 event was less than 200 microseconds, suggesting a source size of less than 60 km!). These arguments have recently been used by some authors (R. Sunyaev, S. Bonazzola) to propose for gamma-ray bursters a model somewhat similar to that currently accepted for the recurrent X-ray bursters (see THE MESSENGER No. 23) which differ from gamma-ray bursters in intensity, spectrum and recurrence but have time scales analogous to some gamma-ray bursts. The gamma-ray bursts would be due to thermonuclear flashes ($3\ He^4 \rightarrow C^{12} + \gamma$) occurring in the surface layers of neutron stars which undergo a very slow but steady accretion of matter, presumably in binary systems.

Although nearby galactic neutron stars seem the most plausible candidates for gamma-ray burst sources, the alternative suggestion of an extragalactic (albeit neutron-star-based) origin for the 1979 March 5 event has not yet been completely abandoned by some theorists in spite of the rather incredible values of burst luminosities that it would imply ($3\ 10^{44}$ ergs/sec if at the distance of the LMC). Therefore, optical identification of these sources is still a crucial task. And it requires a detailed, time-consuming study of all the faint optical objects in the small error boxes derived for some of the best-studied gamma-ray bursts.

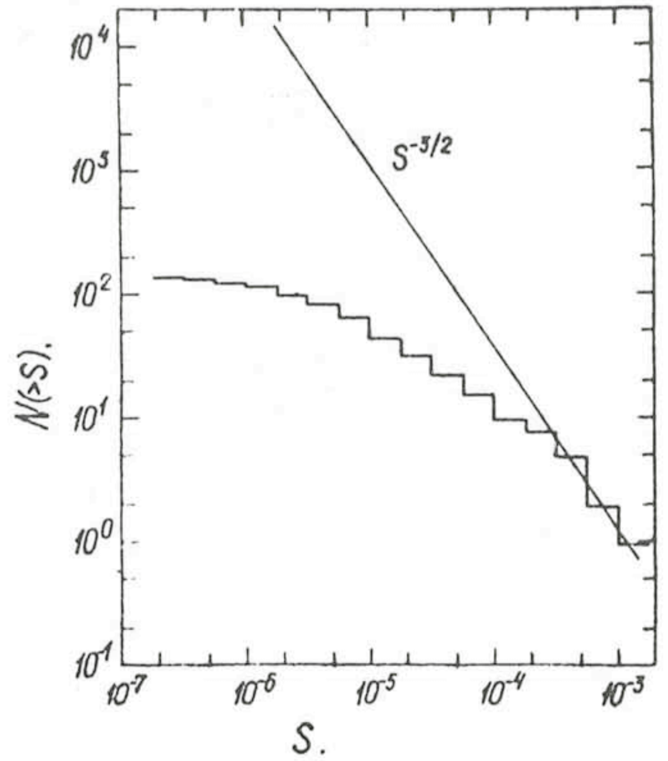

Fig. 4: *The log N-log S distribution for the 43 γ-ray bursts recorded from September 1978 to February 1980 by the Russian Konus experiment on the Venera 11 and 12 spacecraft (from Mazets et. al. 1980).*

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ESO Conference on the "Scientific Importance of High Angular Resolution at Infrared and Optical Wavelengths"

The conference on the "Scientific Importance of High Angular Resolution at Infrared and Optical Wavelengths", announced in the last issue of the MESSENGER, took place in the ESO headquarters at Garching on 24–27 March 1981. It was attended by 91 participants from 13 countries.

The aim of this conference was to help deciding if the large telescope of the future should be made of a single 16 m mirror or of several smaller aperture telescopes forming an interferometer. Accordingly, present achievements of both speckle interferometry and interferometry with multiple systems were extensively discussed together with the theoretical limitations of these techniques. Then the needs for high angular resolutions in all fields of astronomy from the solar system to the galaxies have been presented.

Good arguments have been given for both solutions, single and multiple apertures. Some lively discussions on this subject have shown that any decision would be premature.

The workshop proceedings will be published by ESO in a few weeks. *P. V.*

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

FLEBUS, Carlo, I, Laboratory Technician, 1.5.1981
MÜLLER, Karel, DK, Administrative Assistant (Accounting), 1.5.1981
TANNE, Jean-François, F, Project Engineer in Astronomical Instrumentation, 1.7.1981
HUSTER, Gotthard, D, Designer-Draughtsman, 1.7.1981
MEYER, Manfred, D, Electronics Engineer, 1.10.1981
KRAUS, Hans-Jürgen, D, Driver/General Clerk, 1.7.1981
MALASSAGNE, Serge, F, Designer-Draughtsman, 1.8.1981
PONZ, José, E, Science Applications Programmer, 1.10.1981

Departures

Europe

SCHULTZ, Raimund, D, Driver/General Clerk, 15.5.1981
SCHABEL, Peter, A, Senior Electr. Engineer, 31.8.1981

ASSOCIATES

Departures

Europe

LINDBLAD, Per Olof, S, 31.8.1981

FELLOWS

Arrivals

Europe

BJÖRNSSON, Claes-Ingvar, S, 1.10.1981
GILLET, Denis, F, 1.10.1981
WOUTERLOOT, Jan, NL, 1.10.1981

Departures

Europe

PAKULL, Manfred, 31.5.1981

Photometric, Spectroscopic and IUE Observations of X-ray Binaries

H. Mauder, University of Tübingen

Introduction

X-ray binaries offer the unique opportunity to study the properties of neutron stars in some detail. In a recent article E. J. Zuiderwijk (THE MESSENGER No. 19, p. 18, 1970) discussed the "Standard Model" of X-ray binaries with massive components, demonstrating the difficulties in lightcurve analysis and mass determination. The model is relatively simple: a normal primary star, which can be observed in visual light, and a neutron star form a binary system. The most important constraint is given by the "Limiting Roche Lobe", a critical surface, which is confining the maximum possible radius of the primary star. The size of this lobe, in units of the separation of the two stars, is dependent only on their mass ratio. Thus the radius of the primary star gives a limiting value for the mass ratio.

It is assumed that the optical star is in bound rotation, which means that the rotational period of the star is identical with the orbital period of the binary system. Thus, the orientation of the star relatively to the axis connecting both components is constant, an assumption which seems quite plausible due to the strong tidal deformation in very close binary systems. If, however, the primary star shows unbound rotation, then the size of the limiting lobe is different from the normal case of bound rotation and as a consequence, a different value for the mass of the neutron star is possible.

Another problem is the mass transfer, which is necessary to make the binary star an X-ray binary. The kinetic energy of the gas falling onto the neutron star is converted into heat, at the surface of the neutron star a temperature of about 10^7K is reached, giving rise to strong X-ray emission. There are two possible mechanisms for the mass transfer: Either the primary star, due to its evolution, has expanded up to its limiting Roche lobe and the matter overflowing this lobe is falling on the neutron star, or the primary star loses mass due to a strong

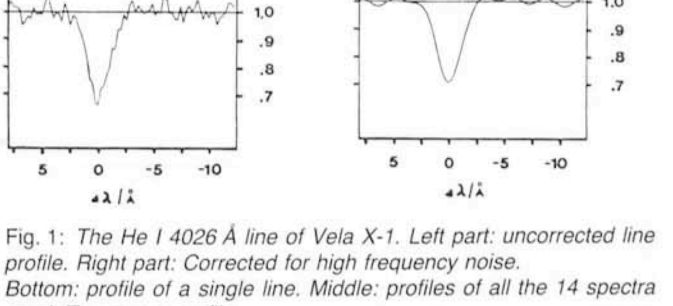

Fig. 1: *The He I 4026 Å line of Vela X-1. Left part: uncorrected line profile. Right part: Corrected for high frequency noise. Bottom: profile of a single line. Middle: profiles of all the 14 spectra used. Top: mean profile.*

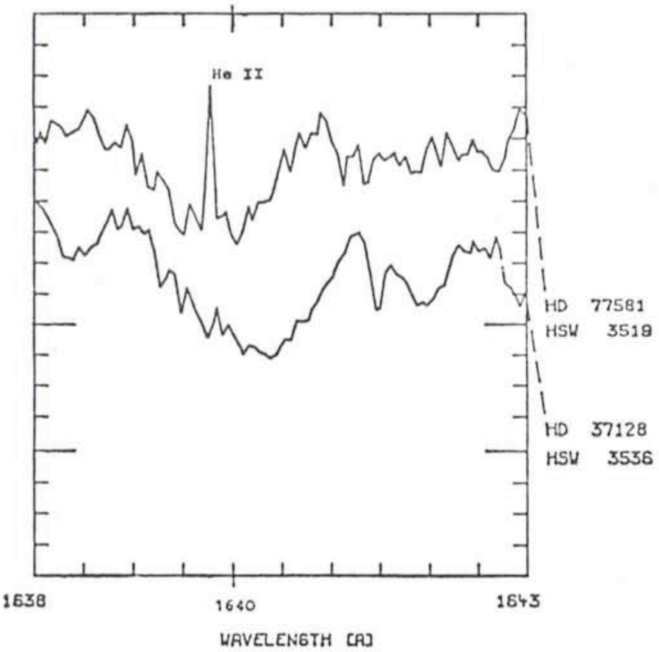

Fig. 2: *A comparison of the He II 1640 Å line profile of Vela X-1 (top) and HD 37128 (bottom). The rotational broadening is very similar in both stars. The spike in the Vela X-1 spectrum is due to an error (saturated pixel) in the image transmission from the satellite to the earth.*

stellar wind. In massive X-ray binaries, the second case seems to be present. Thus, a detailed study of the properties of the stellar wind will give information on the connection with the X-ray emission.

The Unbound Rotation of Vela X-1

According to the results cited by Zuiderwijk, the equatorial velocity of the optical component in Vela X-1 should be v_{eq} sin i = 175 km/s in the case of bound rotation, where i is the inclination of the axis of rotation against the line of sight. This rotational velocity should alter the profiles of the spectral lines and it is possible, therefore, to derive the value v_{eq} sin i from the line shape (Fig. 1). As an example, the He I 4026 Å line of Vela X-1 is shown, from Coudé spectra taken with the ESO 152 cm telescope at 20 Å/mm. Using the Fourier Transform Method it is possible to correct the intensity tracings of the spectra for the high frequency part of the photographic noise. In the left part of the figure, the uncorrected tracings are shown, in the right part the corrected ones. Bottom is a single line, the middle gives the tracings of all 14 spectra used and at the top the mean line is shown. Applying a Fourier-Bessel-Transformation on these line profiles gives the velocity v_{eq} sin i. This was done for several He I lines; as a result, v_{eq} sin i = 89 km/s was obtained for Vela X-1. Details of this procedure are described by M. Ammann and H. Mauder (*Mitteilungen Astr. Ges.* **43,** 219, 1978). In addition, the EUV spectra of Vela X-1 and of HD 37128, taken with the IUE satellite, are compared (Fig. 2). HD 37128 is a B0 Ia supergiant, almost exactly the same spectral type as the primary star of Vela X-1, and is known to have a rotational velocity of v_{eq} sin i = 85 km/s. The shape of the He II 1640 Å line is very similar in the spectra of both stars. Thus it can be expected that the rotational velocities are not very different, though the effects of a stellar wind are also important. It is evident, however, that the rotation of the optical component of Vela X-1 is much slower than expected for bound rotation. The rotational critical lobe of the primary star of Vela X-1 is larger than the respective Roche lobe for a given mass ratio; therefore, the minimum mass ratio may be smaller than in the case of bound rotation. As a consequence, the minimum mass of the neutron star in Vela X-1 could be somewhat smaller than 1.74 solar masses.

Stellar Wind

The profiles of spectral lines may be altered remarkably if a strong stellar wind is present. The gaseous matter surrounding the star produces the well known P Cygni line profiles, strong emission lines with violet shifted absorption features.

The line profiles may be very different, according to ionisation, wind velocity and density. As an example, the 1403 Å Si IV line of X Per is shown (Fig. 3), taken from an IUE

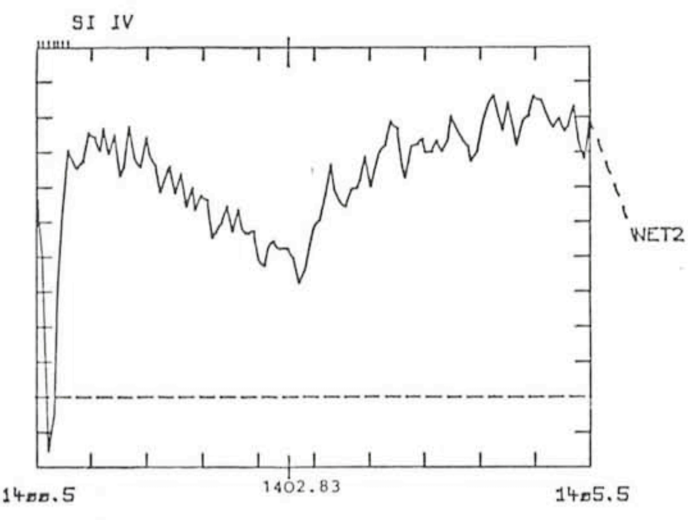

Fig. 3: *Si IV 1403 Å line of X Per. The line profile is very asymmetrical, showing an extended violet wing. This wing indicates a stellar wind of about –350 km/s.*

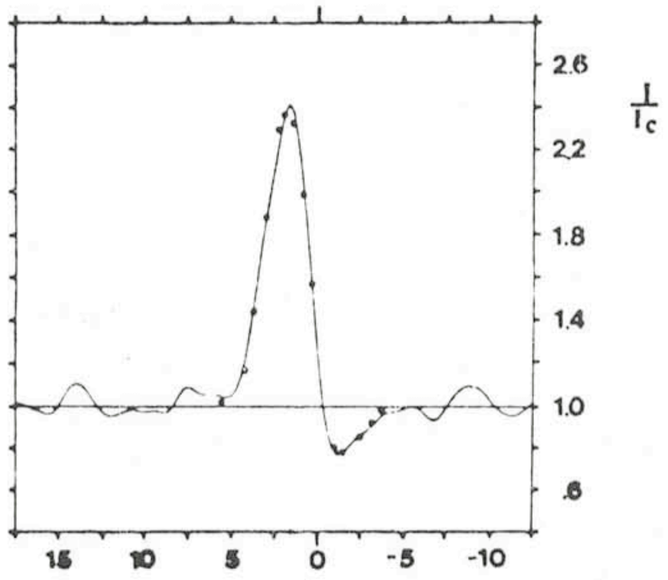

Fig. 4: *Theoretical (dots) and observed (full line) profile of the Hβ line in WRA 977. The physical characteristics of the stellar wind zone surrounding the primary star can be derived in detail from the P Cygni line profile.*

spectrum. Due to the combined effects of emission and absorption, the line is very asymmetrical with a large, violet shifted wing, indicating a wind velocity of about –350 km/s. Further analysis of the EUV spectra will give information on the rate of mass transfer in this X-ray binary system. Another good example is WRA 977 = 3U1223-62. 20 Å/mm Coudé spectra, taken at ESO, show typical P Cygni profiles. Theoretical calculations for the Hβ line give excellent agreement with the observed line profile (Fig. 4). For details see H. Mauder, M. Ammann and E. Schulz *(Mitteilungen Astr. Ges.* **43,** 227, 1978). It is interesting to note, that the stellar wind in WRA 977 must be remarkably variable: spectra, which were taken in 1979, show little or no emission, only the normal absorption components of the Balmer lines are seen.

Optical Burst in Sco X-1

One of the most exciting new groups among the X-ray sources are the X-ray bursters. A review on these objects was given recently by W. Wamsteker (THE MESSENGER No. 18, p. 31, 1979). Optical bursts have been observed from some of these sources, too (see for instance H. Pedersen, THE MESSENGER No. 18, p. 34, 1979). It is now generally believed that the X-ray bursts – and also the optical bursts – are due to a thermonuclear flash on the surface of a neutron star. In normal X-ray binaries, the matter accreted by the neutron star will undergo nuclear burning similar to the processes in stellar interiors. The hydrogen is transformed to helium, helium to carbon and so on until a distribution of elements similar to the equilibrium process is reached. However, in special cases the temperature and pressure at the surface of the neutron star may be too low for this process to take place. The infalling hydrogen is transformed to helium, but helium burning cannot start. Therefore, more and more helium is accreted, until the temperature and pressure reach the ignition point for helium burning: the helium bomb will explode, leading to the burst. The

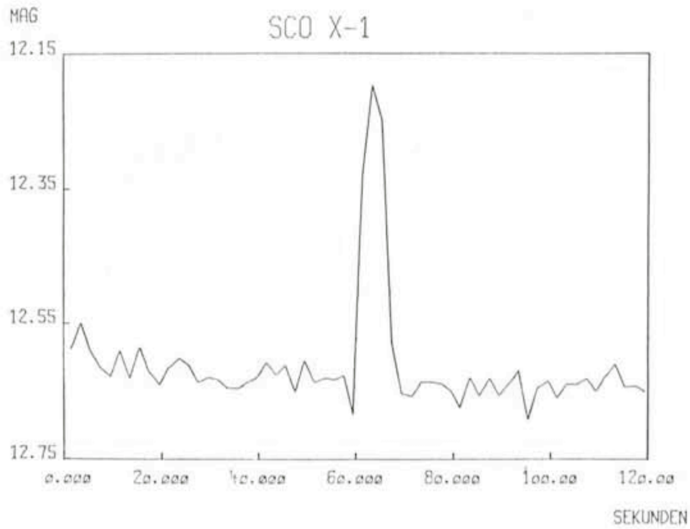

Fig. 5: *Sco X-1 showed a burst event in the optical range on March 13th, 1979, at $7^h\ 29^m\ 49^s$ U.T. This is an indication that the X-ray bursters are very similar objects.*

optical identification of some X-ray bursters showed that these objects are very similar to Sco X-1. The spectra of the X-ray burster MXB 1735-44 and of Sco X-1 are almost identical, even in details. However, no X-ray bursts were detected from Sco X-1 till now, though its X-ray emission is very irregular. In a series of photometric observations, obtained at La Silla with the 1 m telescope with a time resolution of two seconds, an optical burst of Sco X-1 was found on March 13th, 1979, $7^h\ 29^m\ 49^s$ U.T. (Fig. 5). The short duration of only about ten seconds is typical for burst events. Thus, Sco X-1 may be the connecting link between X-ray bursters and normal, low mass, X-ray binary stars.

Millimetre Observations of Quasars

W. A. Sherwood, Max-Planck-Institut für Radioastronomie, Bonn

During an observing run on La Silla in 1978 I noticed a preprint from Wright & Kleinmann concerning their recent infrared (IR) observations of a very luminous quasar, Q0420-388. It had been discovered at Cerro Tololo on objective prism plates by Osmer and Smith. There were several aspects of this object which interested me: it had a large redshift, z = 3.12, and yet its apparent magnitude was brighter than 17 implying a very large luminosity (3C 273 has an apparent magnitude of 13 and z = 0.158); it was not then known to be a radio source (< .22 Jy at 2.7 GHz); and yet the IR and visual intensity gave a shape to the spectrum which would soon reach a value larger than the radio limit if the spectrum were to be extrapolated to frequencies lower than the IR. In fact, extrapolating the spectrum to 1 mm or 300 GHz yielded a flux density greater than 1 Jy which I thought we could measure.

In the submillimetre group of Georg Schultz at the Max-Planck Institute the first successful tests of our composite bolometer system were made in 1978. Ernst Kreysa attended to the cryogenics and electronics, and Michael Arnold put the high and low pass filters together to insure that only radiation at 300 GHz could be measured. Recently Peter Gemünd has made further improvements in the transmission characteristics of the filter.

As is well known, the first quasars were discovered through their strong radio emission which led to their being identified with star-like objects with ultraviolet excess and strong emission lines.

This led to two optical methods, 2-colour photography and objective prism spectroscopy, for finding quasars. For comparison the majority of those found optically (~ 90 %) were either very weak radio sources or were not detected (radio quiet).

This result was certainly unexpected, bearing in mind that it was the strong radio emission which led to the discovery of quasars in the first place.

Are the radio-loud and -quiet quasars intrinsically or extrinsically different?

Intrinsic – most of the optically selected quasars may not be strong synchrotron sources in any part of the spectrum or they might be radio quiet due to some frequency selective absorption.

Extrinsic – the distribution and size of relativistic beams may preclude frequent detection.

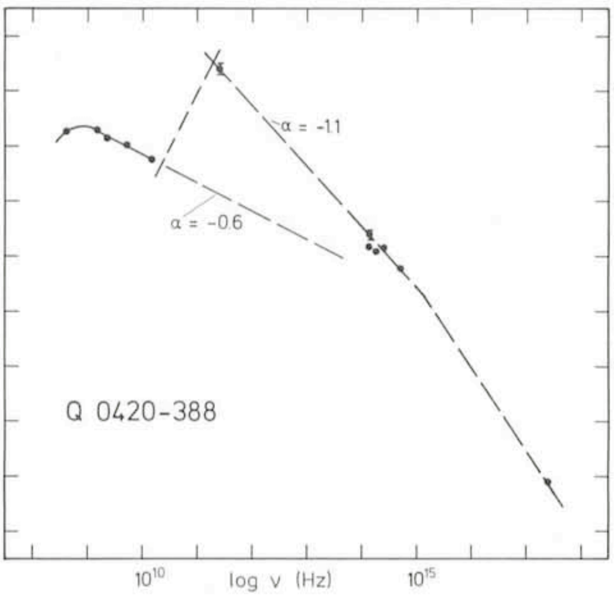

Fig. 1: *The spectrum of the bright quasar, Q0420-388, from the radio to the X-ray region. The error bars are shown where they exceed 10 %. (Fig. courtesy of* Nature).

The quasar Q0420-388, discovered through its strong emission line spectrum, seemed to be a suitable candidate with which to begin a programme of millimetre observations of optically selected quasars. On three nights in September 1979 using the ESO 3.6 m telescope, we detected it. In Juli 1980 on La Silla, we confirmed our detection. In doing so we also confirmed that the spectral index was indeed constant from the optical region to the millimetre range. In the interval between our observations, Q0420-388 was detected in the radio and X-ray regions. The apparent flux density distribution is shown in Figure 1.

With a redshift of $z = 3.12$ the emission from the quasar originated not at a wavelength near 1 mm where we observe it but at a much shorter wavelength below 300 μm. In our galaxy in this wavelength region we find the thermal emission of dust to dominate. Could we be detecting dust in Q0420-388? Theoreticians have predicted the appearance of primeval galaxies as being rich in dust and observers have tried to detect them, so far unsuccessfully. We don't, however, believe that Q0420-388 represents the primeval galaxy type.

One reason is that the thermal emission from dust has a maximum at a shorter wavelength than 300 μm (≤ 100 μm). This component of the spectrum would be independent of the optical/IR spectrum with the consequence that the observed millimetre flux density would have to lie by chance on the extrapolation of the optical/IR spectrum which now extends by at least three orders of magnitude in the opposite direction to the X-ray data with approximately the same spectral index. The continuity of the spectrum could be interpreted as evidence for a single emission mechanism in the absence of support for dust. In a sample of some 40 flat radio spectrum sources we have not found any excess emission which could be attributed to dust. To date no spectrum of a quasar has shown the 2200 Å bump due to interstellar grains when this region of the spectrum has been observed. Furthermore there is no evidence for reddening in the optical spectrum either in the continuum or in the relative line strengths. This may mean that the temperature in quasars is too hot for the heavy elements to form dust.

A second reason lies in the extremely high luminosity exhibited by Q0420-388, $> 10^{15}$ L_0, several orders of magnitude greater than that predicted for primeval galaxies or observed in other dusty galaxies (SgrA, NGC 253). The luminosity at 1 mm is also relatively greater than that expected for dust.

Another reason may be that the millimetre and IR data may show evidence for variability on a time scale too short for a thermal source. This needs to be carefully checked and confirmed.

At the end of 1979 we had reached the stage of asking why we had detected Q0420-388. Was it unique? Was it because it was very luminous or very young as implied by the large redshift? We had chosen, for our July 1980 run, two samples to test the luminosity question: quasars with ultraviolet excess and brighter than $17^m.5$; and quasars with strong emission lines also brighter than $17^m.5$. The redshifts for the first group were ~ 0.5 and for the second group ~ 1.5-2 making the second group, for the same apparent magnitude, the more luminous. It was among quasars of this latter group that we had the higher detection rate ~ 90 % versus ~ 20 %. Yet, even in the first group, the quasars detected appear to have higher than average redshifts, i. e. appear to be the most luminous.

We sought to test this result even more strenuously with a biased sample of quasars with $z > 3.0$ irrespective of apparent magnitude. This is a heterogenous sample representing about 25 % of all the radio and optically selected quasars known with $z > 3.0$.

We have 3-sigma detections for all 8 objects which we had time to observe. The spectra are shown in Figure 2. The faintest object has $B \sim 20^m.5$, $z = 3.17$, and the most distant object has $z = 3.49$, $B \sim 19^m$.

We conclude that the radio-quiet quasar phenomenon is an intrinsic property of quasars. The phenomenon appears to be a function of luminosity but may easily be a function of another

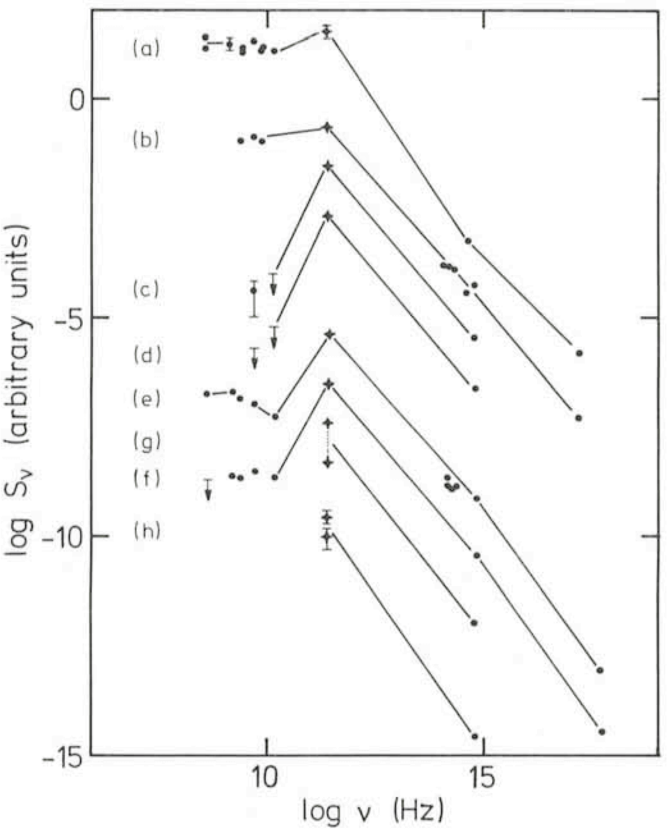

Fig. 2: *The spectra of 8 quasars with z > 3.0. (a) PKS 0537-286, (b) PKS 2126-15, (c) 0130-403, (d) 0324-407, (e) 0420-388, (f) 2204-408, (g) 2227-394, (h) 2228-405. The measurements at 1 mm are denoted by "+".*

parameter, such as age/evolution, gas content (mass loss or accretion rate), etc., which is not easily separable from luminosity.

We are grateful to ESO for their support of unorthodox photometry in the far infrared and to the DFG-SFB project 131, Radioastronomy, for financial support.

Discovery and Rediscovery of Comets and Minor Planets with the ESO 1 m Schmidt Telescope

H.-E. Schuster, ESO – La Silla

After a successful night with the ESO Schmidt, having taken plates for the ESO Atlas or for the scheduled non-Atlas programmes, follows the indispensable check and quality control of the plates. Focus behaviour all over the large field, image quality, evenness of development, limiting magnitude, emulsion faults are some of the quality factors to be checked. This is done usually by visual inspection, the plate being put on a light table and inspected through a zoom microscope allowing a magnification of 10 to 40 times. The whole plate is scanned from corner to corner.

During this inspection, every now and then, just by pure chance, a comet or a minor planet is detected. As these objects have a noticeable differential movement against the field stars, they show up as long trails on the plates. The lengths of the trails depend on the "speed" of the objects and on the exposure time of the plate. Sometimes, trails of this kind call special attention because their fuzzy structure or even haziness on one edge indicate that the object may be a comet. From at least three different exposures a preliminary orbit can be calculated and a first ephemeris, and, what is important, the second and the third plates definitely confirm the reality of the object. And finally the repeated plates show if one has not been trapped on the first one (the detection plate) just by a reflection or an emulsion fault. In this stage it is normally also possible to decide whether the object is really "new" or if it is a known one just coming back in our neighbourhood.

In reality, the inspection of plates for comets and minor planets is not as easy as it may look here. There is first a certain effect of getting tired after having inspected some plates and there is also the danger of becoming less attentive and missing an object, especially as they are not always very spectacular. If the motion is slow and the exposure short, the trails may be very short and look like slightly elongated star images.

The aspect of a comet may be even more ambiguous. When far away from the sun, they do not show any noticeable activity or only a very low one. In consequence their trails may look like "normal" minor planet trails. Sometimes, a certain fuzziness promising a comet is faked only by seeing conditions or emulsion behaviour.

If one is sure about the reality of the object, a notice, normally by telex, is given to the IAU (International Astronomical Union) office in Cambridge (Mass.). From there the discovery is made known to other observers and institutes, for confirmation or for further studies of the new member of our solar system. As soon as a reliable set of coordinates has been established, people dedicated to such work will set up the orbital elements (a sort of passport for the object) and calculate an ephemeris for further observations. Of special interest are comets when their orbital and other parameters indicate that they may become bright and spectacular when passing near the earth in favourable observing conditions.

Special classes of minor planets not belonging to the large bulk of so-called main belt asteroids, are exciting for astronomers. Having orbits of high inclination with respect to the ecliptic plane, or being extremely "quick" (that means near the earth), they may cross the earth's orbit and are of high interest for specialized observers. In both cases, as well for comets as for special minor planets, it is very useful to detect them as early as possible, long before their close approach to the earth. Only then observations, and maybe even space missions, can be planned carefully and efficiently and a campaign can be started.

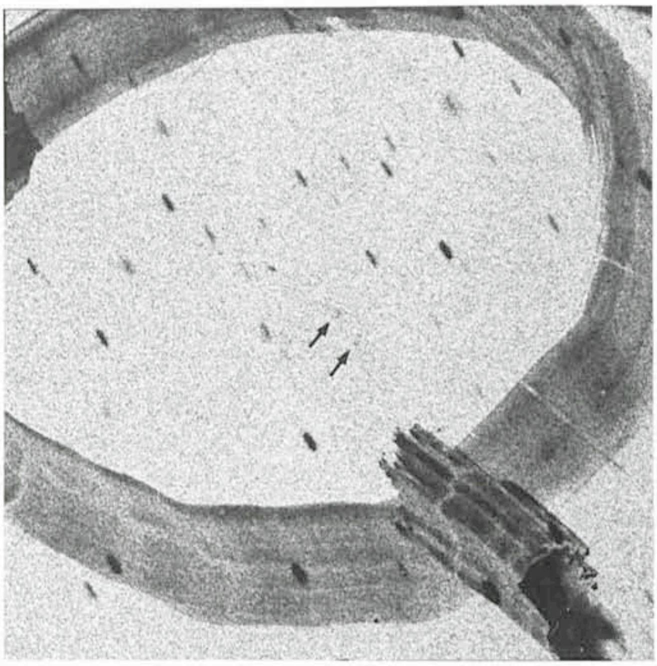

Fig. 1: *Recovery plate of comet P/Brooks, taken by H.-E. Schuster on 12 June 1980. Double exposure, 20 minutes each, on IIa-O emulsion, filter GG385. The arrows show the two images of the comet.*

The MESSENGER has frequently reported during the last years about comets and special minor planets detected on La Silla with the 1 m Schmidt telescope. Also reports on further studies and results have been given. So it is not intended to repeat these notes here.

What has to be stressed is the following: All the minor planets and comets found on La Silla with the Schmidt telescope are an accidental by-product of other programmes. No systematic long-time "hunting" has been done.

A more systematic and planned enterprise is the so-called recovery of known comets and minor planets. Here the time and the coordinates are known with some accuracy, when and where on the sky a periodic comet or a minor planet will show up again. It is of course not so spectacular and exciting to recover a known object than to detect a new one. But often, orbits and periods are not so well established and there are cases where an object has been lost. That may happen if during the first apparition (the detection event) only a few and maybe not very accurate observations were done. Sometimes the second apparition, when the object has finished its first revolution, is missed for bad weather. Consequently, the orbit is not very well known. During their travel through the solar system, periodic comets may pass near to one of the large planets. Then a drastic change of their orbital elements may take place. Such changes are ruled by pure celestial mechanics, but comets may also undergo other orbital changes not governed by Keplers laws. Such "non-gravitational" forces are not well understood yet.

So the return of a periodic comet and of some minor planets is still an exciting adventure, when such an object, after years, in case of periodic comets maybe up to 80 years and more, comes back to us after its long travel in deep space. That will happen soon with the famous comet HALLEY which after 76 years will visit us again.

And there is a certain tension of course: who will detect it first on its way back to us?

If one has some idea about the orbit, the recovery of these objects is not any more just "fishing" in the sky. One knows at least where to look, and when, what movement could be expected and what magnitude.

The ESO Schmidt telescope was very successful during the year 1980 in recovering comets and minor planets. 6 periodic comets were recovered (table 1) well before their perihelion (nearest approach to the sun) and one minor planet, the long lost HELLA, MP1370 (Schmadel, 1980, *Astronomische Nachrichten,* **301,** 251).

The recovery of the 6 comets was more or less a "routine", but the recovery of minor planet HELLA was something special. This object was observed for the first time in 1935 on a few exposures by Reinmuth in Heidelberg. From then on, for 45 years, the planet was not observed and finally listed as lost.

A careful study by Lutz Schmadel (also from Heidelberg) resulted in a search ephemeris telling us where to look for the object. Using Schmadel's computations, it was possible with the ESO Schmidt to recover minor planet HELLA after 45 years.

TABLE 1

List of periodic comets recovered at La Silla in 1980

P/Forbes	P/Borelly
P/Brooks 2	P/Kohoutek
P/Stephan Oterma	P/West-Kohoutek-Ikemma

Technically the work on the recovered comets and on HELLA has been made possible by a simpel, but powerful device integrated now to the Schmidt guiding system.

Normally, for regular plates, a guide star is put on the cross-wire of the television screen. When this is carefully done, all the stars on the plate will show up as distinct points, and a moving planet or comet will be seen as an elongated trail. One has to realize that doing this for the trailed comets or minor planets would be "wasting light". In this way, the objects we are looking for are moving over the plate and in a simple way one could say that faint objects do not stay long enough on any given spot to tell the emulsion "here I am". Only brighter moving objects can be detected, which mark a sufficiently strong trail. With the ESO Schmidt, for this kind of trailing, the detection limit is about 17th magnitude, depending of course also somewhat on the "speed" of the object. What is done now is the following: the electronic cross-wire on the TV screen is shifted according to the expected movement of the object under study, under computer control. Keeping the guide star on the cross, all stars on the plate will show up as elongated trails but the minor planet or comet under study will become a point. And the detection limit is pushed to the 19th, or even, under good conditions, to the 20th magnitude, depending a little bit on the quality of the precalculated parameters for the cross-movement. So, knowing more or less the movement of the returning object, one may redetect them when they are still faint.

The computer-controlled cross-wire, implemented some time ago to the Schmidt guiding system by the ESO engineers, has been proven to be a very useful and powerful tool in hunting for lost minor planets or recovering periodic comets. A similar system will also be integrated to the 3.6 m triplet guiding system.

For the year 1981 we have a list of candidates to be recovered with the ESO Schmidt telescope, and we hope to be as successful as last year.

H II Regions in Nearby Galaxies

M. Rosa, Landessternwarte Königstuhl, Heidelberg

1. Introduction

In the past decade the interest in emission nebulae in external galaxies has increased significantly. Although the titles of papers on extragalactic research often do not refer explicitely to the fact that the emission spectra of gaseous nebulae have been investigated, a closer look shows that a considerable fraction of that work is based on data obtained from the study of H II regions. In Section 2 I shall try to outline the importance of H II regions in extragalactic astronomy. Section 3 discusses the problems which are still open and form the background of my own work. Finally, some new results are presented and briefly discussed.

2. Previous Work

As soon as closer attention was given to the extragalactic nebulae, observers noted the bright diffuse patches in irregular galaxies and in the arms of spiral systems. As an example Figure 1 shows a blue photograph of the giant Sc galaxy M 101. Very large associations of young stars and H II regions can be seen in the outer parts of the spiral arms. Some of them have their own NGC numbers and their sizes of 10 to 20 arcseconds correspond to linear dimensions of 400 to 800 pc.

Apparently the first one to observe the spectrum of such a giant H II region in an external galaxy was H. Vogel of the Potsdam Observatory in 1890 (!) (cf. Scheiner, Spectralanalyse der Gestirne, p. 254, 1890). In the H II complex NGC 604 in the galaxy M 33 he detected the strong emission lines of Hydrogen and [O III] $\lambda\lambda$ 4960, 5007, thereby establishing the close relationship of this object with galactic H II regions. From that time on, H II regions were used as "wavelength standard sources" to determine the recession velocities of galaxies and the rotation curves of spiral systems. E. Hubble *(Astrophysical Journal,* **63,** 260, 1926) found that the relation between the diameters of the nebulous patches and the apparent magnitudes of the brightest stars involved in these H II regions of M 33 closely resembled a similar relation for galactic H II regions. He used this fact as a piece of evidence for the extragalactic nature of the Local Group galaxy M 33.

Today, the diameters of giant H II regions serve as "yardsticks" in the extragalactic distance scale. They bridge the gap between nearby galaxies, where stellar distance indicators can be used, out to the remote systems, where the Hubble law can be applied. The discrepancy between the present values of the Hubble constant depends strongly on the calibration of diameters and distances of H II regions in M 101 and a few more nearby galaxies.

Most of the more recent investigations of giant H II regions in external galaxies try to derive the physical conditions in these objects. These include the determination of chemical abundances, the study of star formation rates, initial mass functions and heavy element enrichment in galaxies (see for example Audouze, Dennefeld and Kunth, THE MESSENGER No. 22, p. 1, 1980).

3. Basic Problems in the Study of Giant H II Regions

The objective of my research programme is the study of the stellar populations which are located in the cores of the giant H II regions in nearby galaxies and in particular the star formation rates and initial mass functions in galaxies of different types. There are two sources of information: On the one hand we can study the emission spectrum of the gas and derive from these data, with the help of theoretical models of HII regions, the numbers and types of ionizing stars needed. On the other hand, we can directly observe the (scattered) stellar light emerging from the cores of these H II regions to search for stellar spectral features and determine the energy distribution from the far UV to the near IR spectral range. In a final step the

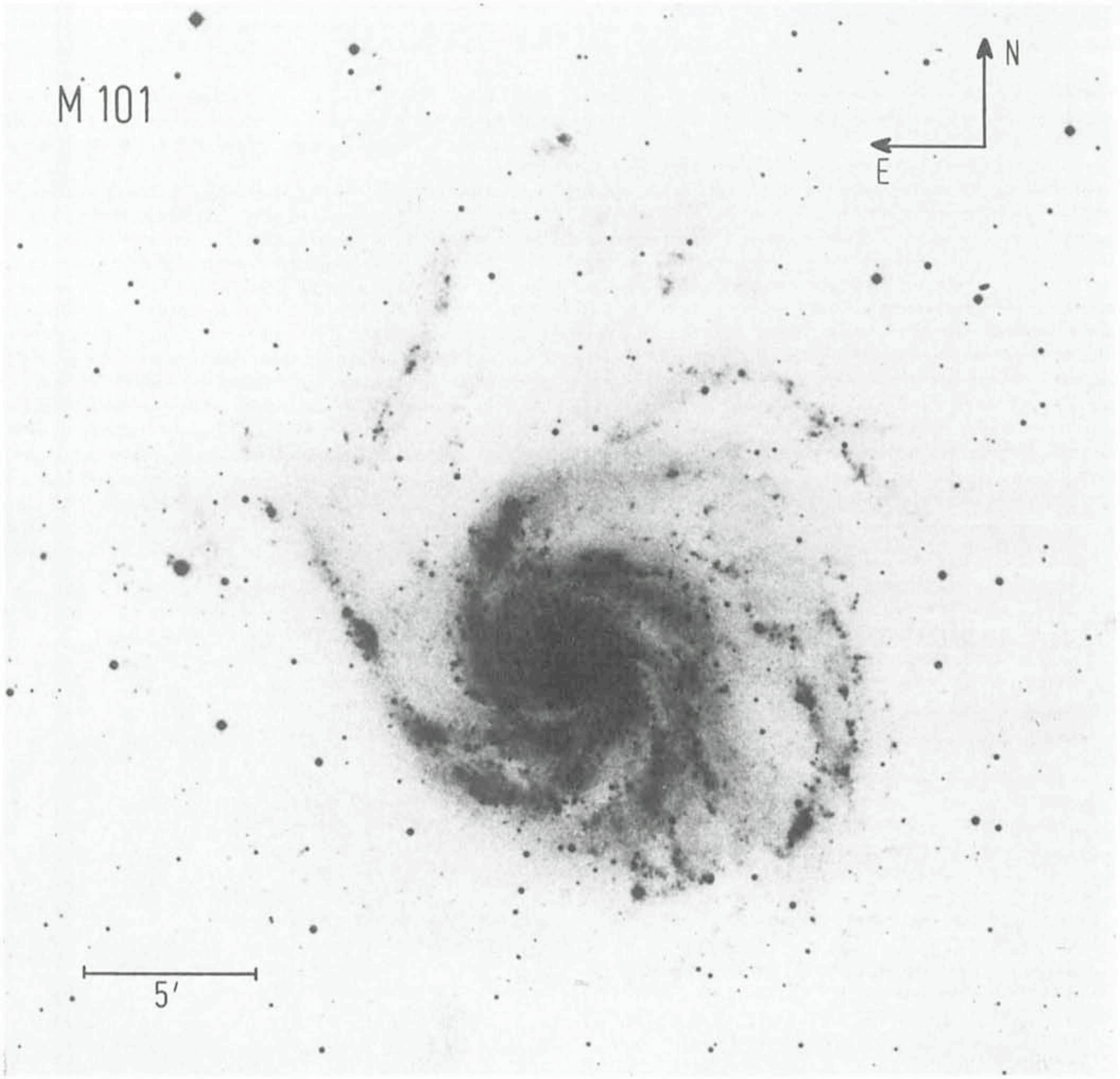

Fig. 1: *Blue photograph of M 101. Note the very large H II complexes in the lower arm extending to the east. (Enlargement from the Palomar Sky Survey print.)*

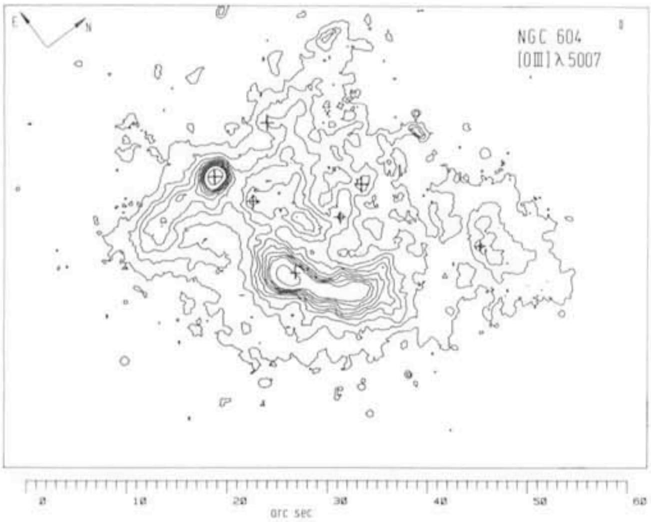

Fig. 2: *Contour map of the core of NGC 604 in the light of nebular [O III] λ5007 emission. Crosses refer to the sources marked in Figure 3.*

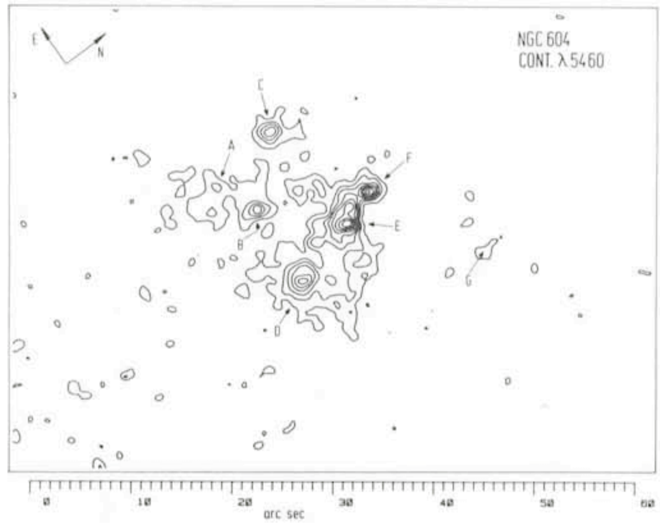

Fig. 3: *Contour map of the core of NGC 604 in a 200 Å wide band centered at 5460 Å (stellar continuum). The brightest knots and the hot spots of Figure 2 are marked by arrows and capital letters.*

results are compared with models of star populations of different ages, mass functions and heavy element abundances.

For most of the H II regions in my programme the data on the nebular emission can be taken from the literature, except for several interesting objects in the southern sky. For the latter, emission line fluxes have been observed with the Image Dissector Scanner at the ESO 1.5 m telescope.

The star light continua, however, had not been given much attention in previous investigations. Due to their faintness they had merely been an insignificant and unwanted background of the order of a few percents of the emission line strengths. Only Searle, in his pioneering spectrophotometry of a large number of H II regions in northern galaxies *(Astrophysical Journal,* **168,** 327, 1971), gave a more detailed description of these continua. Therefore the bulk of my own observations consists of deep spectrograms suitable to search for stellar spectral features and to study the spatial distribution of nebular and stellar light. Long exposure, moderate dispersion image-tube spectrograms have been taken at the ESO 1.5 m and the DSAZ, Calar Alto, Spain 1.2 m telescopes. These spectrograms cover the spectral range from 3500 Å to 7000 Å. In addition, low resolution spectra in the wavelength region 1100 Å to 3400 Å have been obtained with the IUE satellite for the brightest objects. For a number of H II regions the emission line free spectral bands have been observed with the photoelectric scanner attached to the Crossley reflector at the Lick Observatory. These latter observations have been made possible by the generous allocation of observing time by the Staff of the Lick Observatory.

In principle the analysis of the observations is straightforeward. In a first step mean electron temperatures and densities are determined from appropriate emission line ratios. The comparison of theoretical and observed Balmer line ratios yields a reddening correction. The use of a model of the ionization structure then allows us to derive chemical abundances. Of course, corrections are necessary for the unseen stages of ionization, which is very critical in the case of Helium. Finally, the numbers of O type stars needed to ionize the H II regions can be calculated by the use of model atmospheres with proper heavy element abundances. The usual assumption of ionization bound steady state H II regions results in lower limits of these numbers. The spectrophotometry of the stellar continua has to be corrected for the contribution of light from the underlying galaxy, which can be done by properly positioning the "sky" observations. These continua have then to be corrected for scattering and absorption by the dust in the H II regions.

In practice the analysis of the observational data is not that simple. Two serious problems are encountered: The first one is that we do not know which H II region model we have to apply. For obvious reasons the theoretical models available are rather simple compared to even the Orion nebula. Most of them have spheric or cylindric symmetry, are homogenous in density and temperature and assume a pointlike source of ionization. Although some models treat zonal inhomogeneities and can be modified with artificial clumping factors, we do not know to what extend they are reliable, since they have to be tested first on H II regions which offer enough spatial resolution. The second problem is the large scatter of reddening values which are derived by different methods. The visual absorptions obtained from the Balmer line ratios are usually one to two magnitudes less than those required by radio observations. This is certainly a reflection of the very complex mixture of gas, stars and dust within the giant H II regions. Reddening corrections are therefore uncertain and depend on the model used – which in turn one wants to derive from the data.

For example, the giant H II region NGC 5471 in the galaxy M 101 contains about 1000 O stars in a core of about 200 pc diameter, ionizing a gas cloud of 10^7 solar masses and it produces 10^4 times the radio power of the Orion nebula. The question is whether the giant H II regions are just "Super Orion Nebulae", i.e. objects like this well-known galactic H II region enlarged many times. Or are they more likely clusters of hundreds or thousands of Orion-like nebulae, possibly faking us with a rather meaningless average spectrum?

Fortunately there is one giant extragalactic H II region relatively close by. It is the famous 30 Doradus complex in the Large Magellanic Cloud. This object is a very inhomogenous mixture of hot ionized regions, cool, dense neutral clouds and hot stars. The large filaments of ionization fronts and the dust lanes make it look like a tarantula. The extinction law is definitely different from the galactic one, the main distinction being the weakness of the 2200 Å feature. A large fraction of the brightest stars observed in the central cluster of 30 Doradus is of the Wolf-Rayet spectral type and the nature of the strange central object R 136 is still in question (cf. Feitzinger and Schmidt-Kaler, THE MESSENGER No. 19, p. 37, 1979). A closer look at more distant giant H II regions might reveal whether 30 Dor is an exception, or if we can apply our empirical models of 30 Dor to the more remote and generally even larger objects.

4. Some Results on NGC 604

In the following, some results obtained in a study of NGC 604 (the largest H II region in the local group galaxy M 33) are presented. To investigate the morphology of H II regions in nearby galaxies, Rosa, Gaida and Moellenhoff (1981, in preparation) took interference filter photographs at the Cassegrain focus of the 1.2 m telescope of the DSAZ, Spain. As a detector a spectracon tube was used and the images were recorded on Ilford G5 emulsion. The data were digitized using the PDS microdensitometer of the MPIfA, Heidelberg, and reduced with the image processing system of the Landessternwarte Heidelberg. Figures 2 and 3 show the core of NGC 604 in the light of the nebular [O III] $\lambda\lambda$4960, 5007 emission and the stellar continuum at 5460 Å, respectively. At the distance of 720 kpc, 4 pc correspond to 1 arcsec on the sky, a scale 13 times smaller than in the case of 30 Doradus. Comparison of the two figures shows a strong anticorrelation between the hot spots in nebular emission and the maxima of the stellar continuum, marked in Figure 2 and 3. Another qualitative result is the large inhomogeneity of the core of NGC 604 at scales of 10 to 50 pc. For comparison the reader is invited to take THE MESSENGER No. 19, Figure 1 at page 37 (cited above) and turn it around 180 degrees. The similarities between the morphology of the cores of NGC 604 and 30 Dor are striking. Note especially the shapes and positions of the bright rims of nebular emission with respect to the cluster of ionizing stars.

Figure 4 shows the low resolution IUE UV spectrograms of NGC 5471 and NGC 604. In an earlier paper *(Astronomy and Astrophysics,* **85,** L21, 1980) it was found that the UV extinction law of NGC 604 seems to be more similar to that of 30 Doradus than to that of the Galaxy, due to the absence of a pronounced 2200 Å feature. The very strong P Cygni profiles of the lines of e.g. C IV and Si IV reported in the paper quoted above indicate very strong mass loss from the observed stars. This led to the suggestion that a number of Wolf-Rayet stars might contribute to the observed UV spectrum (cf. D'Odorico et al., Proceedings of the ESO/ESA Workshop on Dwarf Galaxies, Tarenghi and Kjär edts, p. 103, 1980).

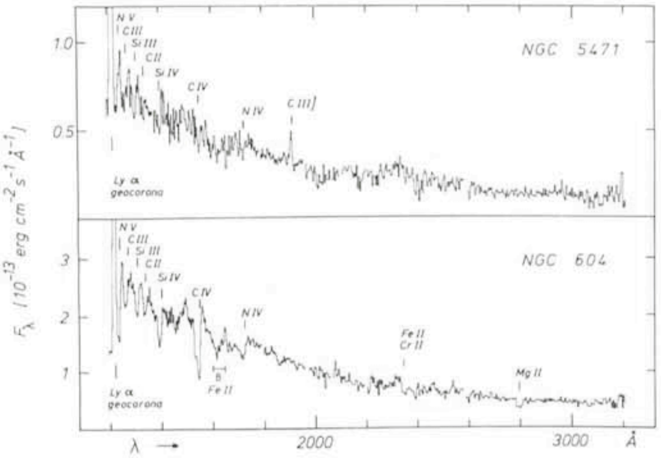

Fig. 4: *Low resolution IUE UV spectrograms of two extragalactic H II regions. Note the strong P Cygni profiles in the tracing of NGC 604.*

To investigate the nature of the bright knots in NGC 604, D'Odorico and Rosa (ESO preprint 143, 1981) observed the blue visual spectra of knots A,C,D,E and F with the IDS attached to the ESO 3.6 and 1.5 m telescopes. Figure 5 shows the spectrogram of knot E which led to the discovery of Wolf-Rayet stars in NGC 604. The logarithmic intensity scale enables to see the Wolf-Rayet emission bands blueward of He II λ4686 and He I λ5876 together with the 100 times stronger nebular emission lines. These observations imply the presence of about 50 Wolf-Rayet stars in a cluster containing about 50 O type stars responsible for the ionization. This is again similar to the situation found in the core of 30 Doradus. The cause for the high ratio of the number of WR to O type stars is as yet unknown. The ratio found in our galaxy is 10 times less

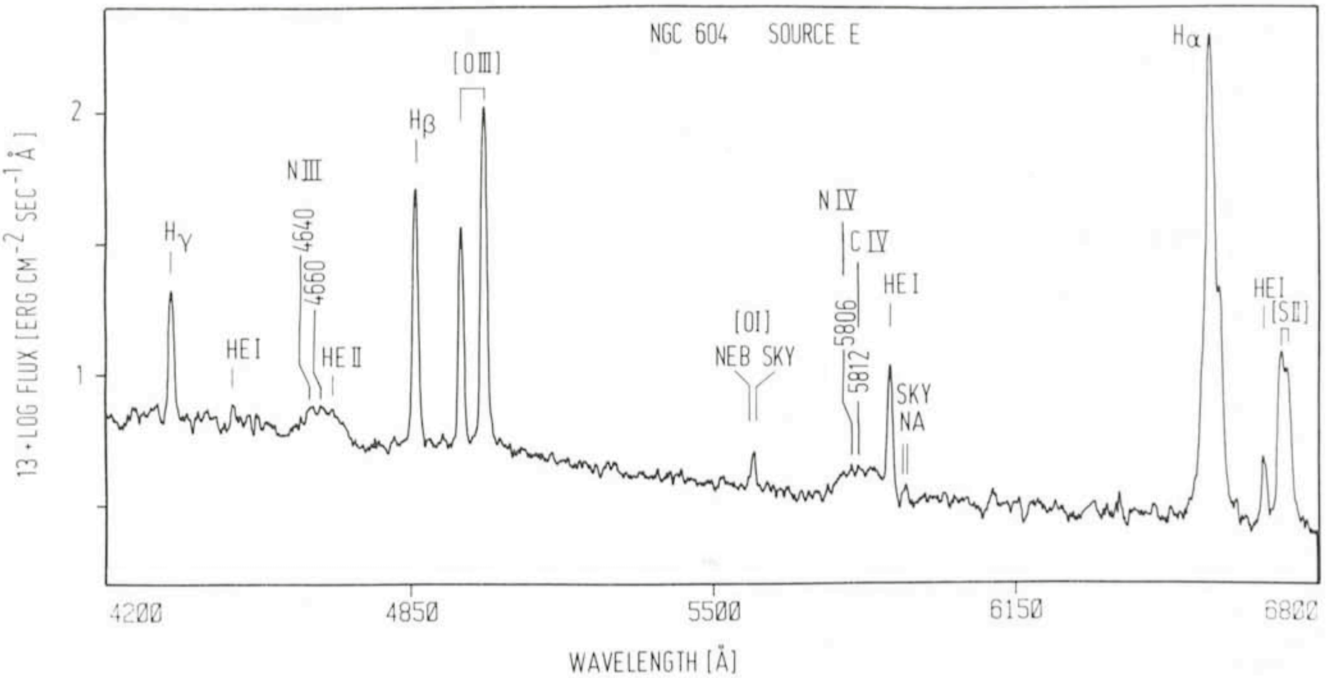

Fig. 5: *IDS spectrogram of knot E (Figure 3) in NGC 604. Emission lines typical of Wolf-Rayet stars are marked with additional wavelength information.*

on the average and may be the equilibrium ratio in the case of continuous star formation. The high ratio found in NGC 604 might then be interpreted as the appearance of a stellar population which has been formed in a single burst about 4×10^6 years ago.

If these high number ratios of Wolf-Rayet stars are found to be common in giant H II regions, they will have large implications on our knowledge of both the WR phenomenon and the star formation and stellar evolution in giant H II regions in external galaxies.

Spinning Asteroids and Photometry: A View of a Modern Topic

H. J. Schober, Institute for Astronomy, Graz, Austria

Introduction

When I first applied for telescope time at ESO in 1976 to carry out photometry of asteroids, I had no idea about the impact of such a programme. As a matter of fact, photometry of asteroids is a method to study those objects in detail for their physical properties such as rotation rates, diameters, surface properties, albedo, geometrical configurations, orientation of rotational axis in space, even masses and densities.

In the meantime quite a number of active asteroid observers have joined and a close cooperation started a few years ago; groups at Torino (F. Scaltriti, V. Zappalà), Brussels (H. Debehogne), Liège (A. and J. Surdej, formerly at ESO), Uppsala (C. I. Lagerkvist) and myself at Graz contributed to the success of the observations of minor planets. Still, the center for collecting all data of asteroids is Tucson-Lunar and Planetary Laboratory, where the TRIAD-file (Tucson Revised Index of Asteroid Data) is maintained, and updated. Though there are many different methods to obtain physical data of asteroids, including infrared, polarimetry or spectrophotometry, I restricted myself to conventional photometry with the main goal to obtain rotation rates, lightcurves and UBV data for an individual asteroid.

Rotation Rates

Times when we considered an asteroid only as a moving pointlike source of light are over. We use ephemerides of course to find and identify objects (you should try to identify a faint asteroid at the beginning of a night on the telescope, if near the Milky Way) and later on, orbital parameters for statistical reasons. If successful in finding the asteroid to be observed (sometimes a few of them in a single night), we follow the object like doing photometry of a variable star, but considering that the object is moving; sometimes fainter stars are included in the diaphragm and those data have to be eliminated, sometimes reidentification in different nights is more difficult.

After successful observations we hopefully obtain an accurate period of rotation of the asteroid body; periods range from only $2^h.27$ (1566 Icarus) and up to $80^h.00$ (182 Elsa). The distribution of rotation periods roughly peaks between $5^h - 11^h$, but nobody really knows if those periods are generally preferred in the solar system, or if this is caused only by a selection effect.

In Fig. 1 the enormous increase of our knowledge of asteroid rotational data in the last years is shown, leading now to a good data material for statistical analysis. From the histogram of rotation periods we may obtain the following facts:

(a) although the number of observed asteroids has increased by a factor 5 since 1975, still the major part rotates with a $5-11^h$ period.

(b) long periods (slowly spinning objects) show up due to observations carried out carefully or with more patience: 654 Zelinda $31^h.9$ (1975) 393 Lampetia $38^h.7$ and 128 Nemesis $39^h.0$ (1979), 709 Fringilla $52^h.4$ (1979) and finally 182 Elsa with $80^h.00$ (1980), which corresponds to $3^d.33$.

Rotational rates of 1^d or $0^d.5$ are difficult to observe, and there may be quite a large number of asteroids showing rotations much longer, but never observed, as phase and/or geometric effects cover the variability due to rotation only, if amplitudes are small.

Lightcurves

Observed lightcurves mainly represent the geometric configuration – either we get double-mode lightcurves with primary and secondary extrema with amplitudes between 0.00 and 1.50 mag, or single-extremum lightcurves if variations are caused only by albedo spots on the asteroid surfaces – but both effects can be present at the same time. Frequently we remarked that we had to double the value of a period (or got half the value) obtained earlier, because of those effects. But also more complex lightcurves do show up with well defined triple extrema, and we leave it to the reader to imagine an interpretation of such a lightcurve in terms of asteroid configuration.

The form and amplitude of a lightcurve is changing if observed at different aspect configuration, representing the changing triangle asteroid-sun-earth, and due to different views onto the asteroid rotational pole. Under special conditions and with accurate timings of extrema it is possible to obtain the orientation of the axis and even the sense of rotation.

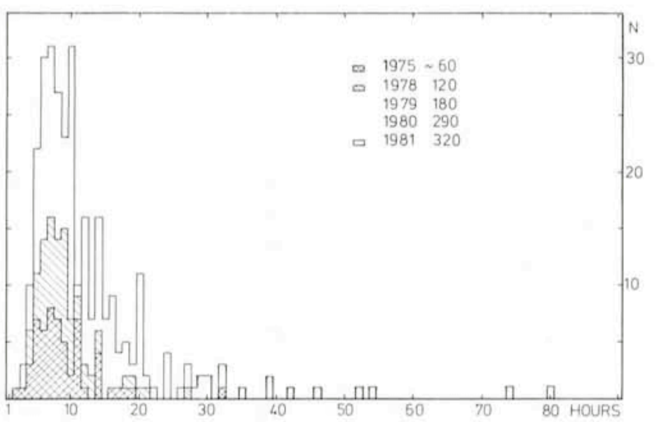

Fig. 1: *The frequency distribution of known rotation periods of asteroids (many of them observed at ESO). Before 1975 the longest rotation period observed was 20 hours – today we reach 80 hours or 3.33 days.*

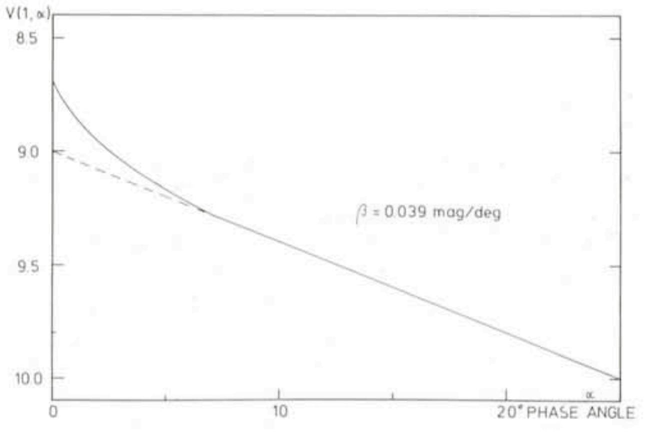

Fig. 2: *The mean magnitude phase relation of an asteroid, where V (1, α) is reduced to unit distances (1 AU), showing an opposition effect at smaller phase angles.*

In this article I do not show lightcurves as this was done earlier in "The Messenger" No. 13, p.3 (J. and A. Surdej, 1978), No. 18, p.27 (Debehogne, 1979) or No. 22, p.5 (C. I. Lagerkvist, 1980).

Magnitudes and UBV Data

Though my main goal is not to get a survey of UBV data, they should be determined each time when observing an asteroid. The magnitude V is essential to get out of a completely observed lightcurve a mean magnitude at a given phase angle. Drawing a plot of magnitudes against solar phase angles we get a phase coefficient, usually about 0.039 mag/deg, but values of 0.015 or 0.050 are not uncommon and conclusions about the surface texture may be obtained. Fig. 2 shows, for a fictive asteroid, that the relation between about 7–20 degrees is linear; but starting with 7 degrees down we have an opposition effect, the nonlinear increase of brightness, with a number of possible explanations for this effect, such as changing reflection properties, shadowing effects, or a new multiple-scattering theory, including the knowledge of macro- and microscopic surface properties. Phase coefficients may be different for S and C type asteroids, but still it is up to the user to make his own choice. To obtain the phase coefficients (at least when observing at ESO for short runs only!) it is necessary to cooperate with other observers carrying out a similar programme.

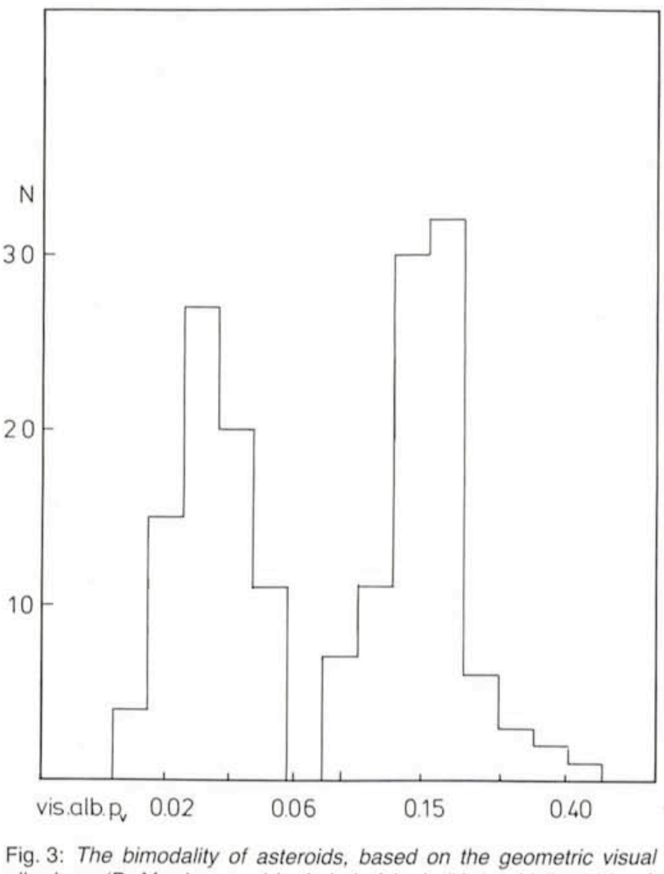

Fig. 3: *The bimodality of asteroids, based on the geometric visual albedo p_v (D. Morrison and L. A. Lebofsky in "Asteroids" p.184, ed. Gehrels T., 1979.*

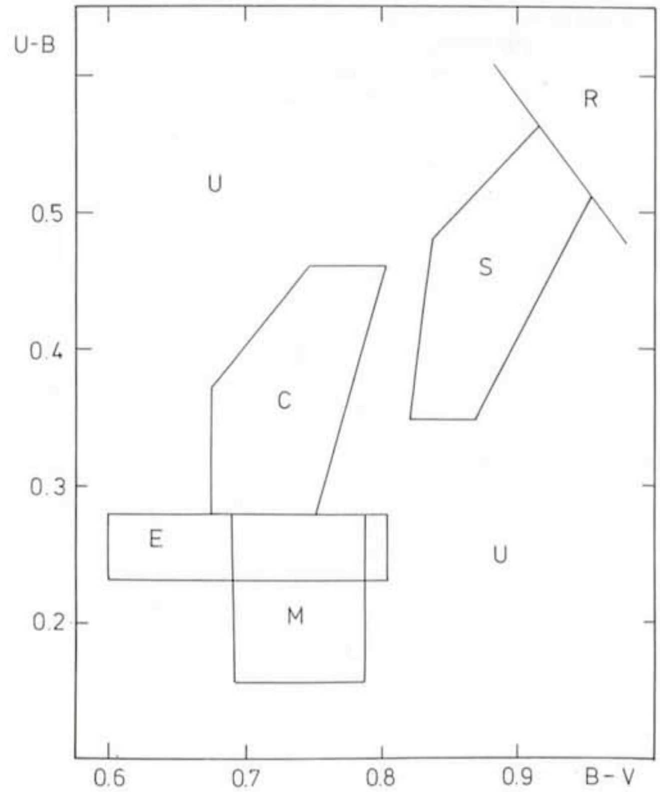

Fig. 4: *Simplified domains of asteroid types C, S, M, E, R from UBV Colours as obtained by E. Bowell et al. (Icarus* **35,** *313, 1978).*

Speaking about C or S types, a taxonomic system to describe asteroids was introduced. Most asteroids fall into two major groups, bright S-types (stony irons, silicaeous) with moderate high albedo of 0.15, and dark C-types (carbonaceaous, chondrites) with only about 0.03–0.05 albedo. The two groups definitely exist as shown by the measurement of the albedo by polarimetric or radiometric methods, as indicated in Fig. 3. In addition to that we know of a few more groups, such as M asteroids (metallic), E, R and U (unusual). The two-colour diagram B-V/U-B in Fig. 4 shows the domains where different types seem to be concentrated. Of course, colours are not the only parameters for the classification.

Though there would be much more to say about that new interesting field in astronomy dealing with well-known objects so near to us, I want to finish this short review with a remark:

I have to thank especially ESO for making available to me so much telescope time, though Austria is not (yet) a member state – and last not least our Austrian "Fonds zur Förderung der Wissenschaftlichen Forschung" which helped to balance the travel budget.

OH Infrared Stars – Very Long Period Variables with Enormous Mass Loss

D. Engels, Sternwarte der Universität Bonn

Since 1975 infrared photometers attached to the ESO 1 m telescope have been used to investigate OH/IR stars. Monitoring them over five years, G. V. Schultz and W. A. Sherwood from the Max-Planck-Institut für Radioastronomie in Bonn and the author proved that OH/IR stars are long period variables, which in extreme cases have periods longer than four years.

In 1973 the first radio survey for OH maser emission at 1612 MHz in the galactic plane was completed by Anders Winnberg and his colleagues. They discovered more than 30 OH sources, showing the double peaked velocity pattern (Fig. 1) characteristic of the OH emission observed in Mira variables and M supergiants. Because of this and because no optical counterparts were found, they were thought to be associated with very red stars and hence called OH/IR sources

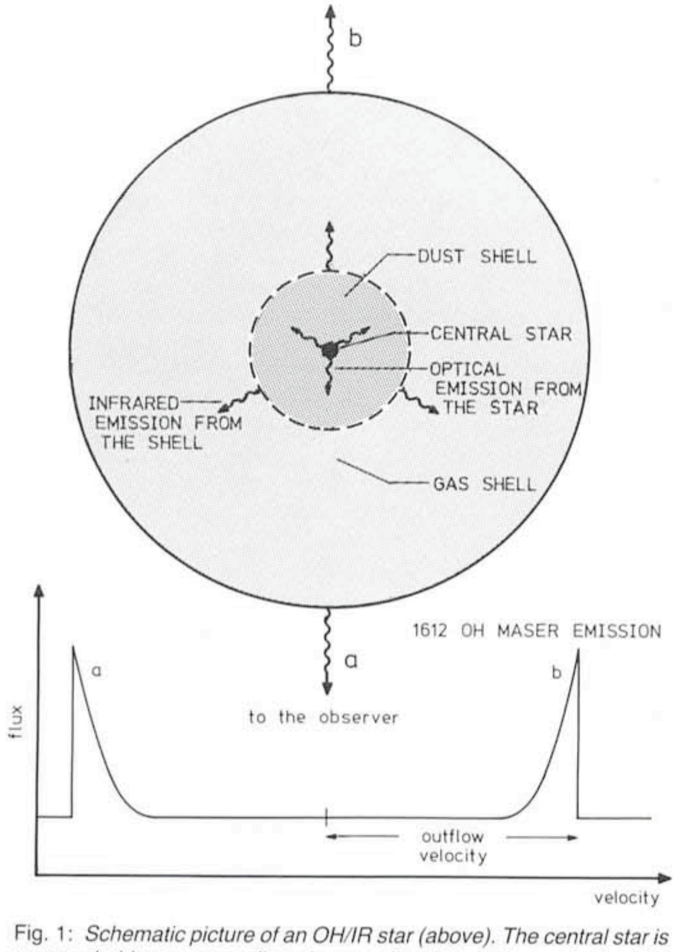

Fig. 1: *Schematic picture of an OH/IR star (above). The central star is surrounded by an expanding circumstellar dust and gas shell, which absorbs the optical emission from the star and reemits the energy in the infrared. The OH masers are located in the outer parts of the shell. At earth the OH maser emission is observed in two velocity groups (below). The low velocity component (a) comes from the front whereas the high velocity feature (b) comes from the back side of the shell.*

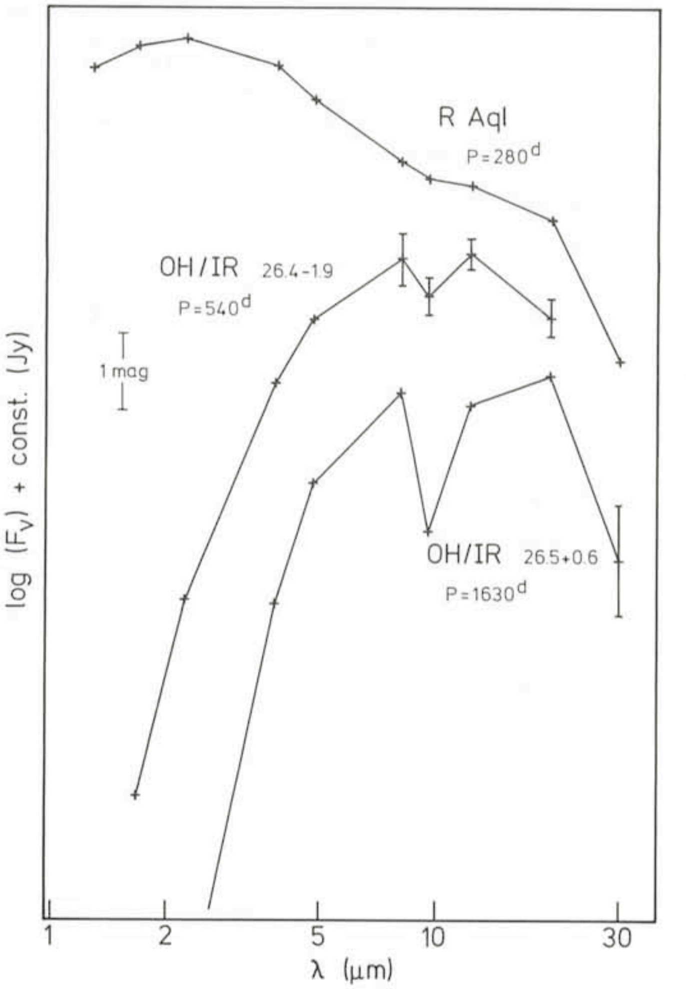

Fig. 2: *Infrared energy distribution measured in July 1980 at the 1 m telescope of two OH/IR stars in comparison to the Mira variable RAql.*

or OH/IR stars, even before an infrared counterpart was detected. The individual objects were named by their galactic coordinates (for example OH/IR 26.5 + 0.6). The association with infrared stars was strongly implicated in 1975 by the first identifications of infrared counterparts at ESO by Schultz, Kreysa and Sherwood (THE MESSENGER, No. 6 and No. 11). To confirm the identifications, Georg Schultz, Bill Sherwood and myself monitored the infrared stars during the following five years, to show that they were indeed variable (in phase with the OH variability) and to determine their periods and the colour temperatures of the dust shells.

Observations

The observations were made with the ESO 1 m telescope using an InSb Photometer cooled with liquid nitrogen in the near infrared ($\lambda \lesssim 5\ \mu m$) and a helium cooled bolometer in the middle infrared ($5\ \mu m \lesssim \lambda \lesssim 30\ \mu m$).

The calibration of the near infrared measurements was improved substantially by us together with Willem Wamsteker, through the set-up of a standard star system for measurements in the filters JHKLM covering the southern sky (see ESO

Preprints, No. 130 and 132, 1980/1981). In the middle infrared the situation was less satisfying, as only a few stars are bright enough to be used as standard stars and the intrinsic energy distribution of these stars is uncertain longward of 5 μm.

The Circumstellar Shells and Mass Loss

Our measurements reveal that the infrared energy distribution of OH/IR stars is quite different from those of known late-type stars having OH emission (Fig. 2). Most of the energy is radiated between 3 and 20 μm with a steep decrease of the spectrum shortward of 3 μm. An absorption feature ascribed to silicate material in the circumstellar shell is present at 9.7 μm. Thus OH/IR stars appear to have thicker shells than those associated with the optically visible Mira variables and M supergiants. Dust shell temperatures range from ~ 400°K for thick shells to ~ 1 000°K for the thinner shells.

The split of the OH emission into two velocity components can be explained by the location of the observed OH masers on the front and back sides of a symmetrically expanding shell. Thus direct evidence for the outflow of material from the star is present. Estimates of mass loss rates are of the order of 10^{-5} $M_\odot$/yr or more. This is one hundred times higher than the mass loss rates derived for Mira variables. In a steady state picture OH/IR stars are loosing in about 10^5 years one solar mass, implying that the duration of the OH/IR phase when high mass loss rates occur must be short.

The Central Stars of OH/IR Sources

We have determined periods for the central stars betwen 500 and 1 700 days (Fig. 3) (cf. Proceed. Workshop Phys. Proc. in Red Giants, 1981, in press). These periods are the longest yet found in the galaxy for long period variable stars. The OH/IR stars we have monitored have been shown to be regular variable stars, with amplitudes up to two magnitudes at 2.2 μm.

To get an idea of the evolutionary phase of the OH/IR sources, the nature of the central stars must be determined. It is still a question whether they are M supergiants or M giants (Mira variables) or whether both types are present among them. The large amplitude variations are in contrast to the behaviour of the galactic M supergiants showing OH maser emission; which generally display small amplitude variations

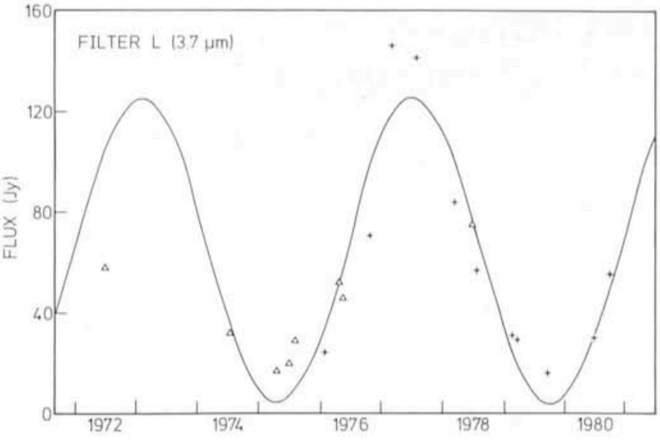

Fig. 3: *Variation of the infrared emission at 3.7 μm of OH/IR 26.5 + 0.6. The period is 1630 days. Crosses are measured at ESO and triangles are taken from the literature.*

and are semiregular. On the other hand the periods have only little overlap with the usual Miras and extend a factor of at least 2 or 3 beyond the longest periods known for Mira stars.

We suggest that OH/IR stars are a rarer, more massive class of Mira variables, which, when they evolve upwards the asymptotic giant branch, begin to pulsate with longer periods and at higher luminosities than the optically visible Mira stars. Indeed we have found that the luminosities do increase with period in a way similar to that for Mira variables. This long period pulsation is connected with increased mass loss leading to the formation of the thick circumstellar shells responsible for the strong infrared and OH maser emission.

What is the fate of these OH/IR stars? With such a high mass loss rate the stars must soon lose their evelopes exposing their hot cores. These cores could then ionize the circumstellar material. Maybe OH/IR stars evolve to planetary nebulae.

Acknowledgement

I wish to thank Prof. H. Schmidt, Bonn, for continuous support of the monitoring project.

Observation of Titan at La Silla during a Total Eclipse

M. Combes, T. Encrenaz, N. Epchtein, J. Lecacheux, Observatoire de Paris-Meudon
T. Owen, State University of New York at Stony Brook

The edge-on presentation of Saturn's rings and satellites system has provided a rare opportunity to observe total eclipses of Titan in the shadow of Saturn. This event, which comes back every 16 years, occurred during the first semester of 1980, and eclipses of several hours were observable every 16 days from November 1979 to July 1980.

Information upon thermal properties of Titan's atmosphere may be expected to be obtained from the observation of Titan during and immediately after its emersion from the Saturnian shadow. It should be pointed out that, in spite of the remarkable results obtained on Titan by Voyager 1, its atmospheric structure is still poorly understood, especially concerning the aerosols.

Titan's emersions were marginally observable from Europe at large zenith distances; more favourable observing conditions occurred in Chile, but emersions occurred close to the time of local sunset.

Observations

We decided to monitor the temperatures of the upper atmosphere and the lower atmosphere (as close as possible to the surface temperature) during and following Titan's emersion. We used a short integration time in order to be able to describe properly a time-evolving situation. The temperature of the upper atmosphere was monitored at 12μ in the C_2H_6 emission band; the surface temperature was monitored at 20μ where most of the outgoing flux comes from the surface. In order to look for a phase change of CH_4, we monitored the Titan spectrum, in the CH_4 bands at 0.6–0.9μ, during and after the emersion.

Observations were performed at La Silla on June 28, 1980, both on the 3.6 m and the 1.52 m telescopes. Monitoring of T_B (12μ) and T_B (20μ)was performed at the Cassegrain focus of the 3.6 m telescope, using an IR photometer designed at Paris-Meudon Observatory (Epchtein, 1981). The filters were centered at 11.3μ and 20.0μ with a FWHM of 1.3μ and 5.0 μ respectively. The typical integration time for a flux determination was 2 mn. Titan's spectrum between 0.6 and 0.9μ was monitored at the Cassegrain focus of the 1.52 m telescope using the Boller and Chivens spectrograph associated with a Reticon camera. The dispersion was 228 Å/mm and the spectroscopic resolution about 6 Å. The slit was a 2 × 2 arcsec aperture. The time needed to record one scan was 5 mn. Spectra of Saturn and the sky were recorded after each Titan scan for comparison.

On June 28, the emersion occurred approximately at sunset (21:45 U.T.). Both the IR and the visible experiment suffered from limitations due to the rapid change in sky brightness with time. Significant data were obtained from 22:05 to 25:30 U.T. from the spectroscopic experiment, and between 22:20 and 25:30 U.T. from the IR experiment.

Results

We did not obtain any indication of a variation of the temperatures at 11.5μ and 20μ versus time, and our values were in agreement with previous observations (McCarthy et al., 1980). So the conclusion of the IR observation is that both the temperature of the upper atmosphere of Titan and the surface temperature were not modified during the 4-hour eclipse.

We did not observe any change in the CH_4 bands (6190, 7250, 7950, 8900 Å) either. The equivalent width of the 7250 Å band, located at the maximum sensitivity wavelength, was 68 ± 5 Å and remained constant within the error bars during the whole experiment; this value is in agreement with previous observations (Wamsteker, 1975). This implies that there has been no change in the CH_4 distribution nor in the scattering properties of the atmosphere after a 4 hours eclipse. This implies that the atmosphere is very stable, and that the aerosols of very large thermal inertia probably dominate the energy budget of the upper atmosphere. This is consistent with a thick atmosphere, predominantly composed of nitrogen as suggested by Voyager 1 results. The present set of observations will provide new constraints upon the new model for Titan's atmosphere that will be based on the Voyager data.

Acknowledgement

We thank C. Perrier, J. Veliz and the whole ESO staff for their cooperation in this programme.

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Upper Limit of the Gaseous CH_4 Abundance on Triton

M. Combes, T. Encrenaz, J. Lecacheux, Observatoire de Paris-Meudon
C. Perrier, ESO, La Silla

Triton, Neptune's largest satellite, has been known for a long time to be able to retain an atmosphere of heavy gases, due to its mass and temperature. Several attempts for detecting the gaseous CH_4 molecule in Triton's spectrum have been inconclusive (Cochran and Cochran, 1977; Cruikshank et al., 1979). In contrast, Benner et al. (1978) reported the identification of a CH_4 gaseous absorption at 8900 Å, as well as Cruikshank and Silvaggio (1979) in the near-infrared; from the second study, an abundance of 7 m-Am (meter-Amagat)* was derived.

A new observation of Triton was recorded on June 28, 1980, at the 1.52 m telescope on La Silla with the Boller and Chivens spectrograph and a Reticon 1024 C camera, in the 6000–9000 Å range. The dispersion was 228 Å/mm, corresponding to a spectroscopic resolution of about 6 Å. The exposure time was 1 hour. The adjacent sky was recorded under the same exposure conditions for comparison. Spectra of the scattered light of the Sun and spectra of Neptune were also recorded for comparison and calibration. The data were degraded to a resolution of 25 Å to improve the S/N ratio (30 at 7250 Å).

There is no trace of CH_4 absorption at 6190, 7250, 7950 and 8900 Å. Using the 7250 Å band which corresponds to the wavelength of maximum sensitivity, the upper limit of equivalent width is 4 Å, which in turn corresponds to an upper limit of 3.5 m-Am for a one-way column abundance of CH_4 on Triton.

Our result is in agreement with the recent result of Johnson et al. (1980) who found from the 8900 Å band an upper limit of 1 m-Am of CH_4 on Triton. The disagreement with Cruikshank and Silvaggio's result might come from true differences in scattering processes in the visible and near-infrared ranges. Additional data are certainly needed in order to reconcile visible and IR observations.

Acknowledgement

We thank the ESO staff for its cooperation in this programme, and Mr. J. Veliz for his contribution in the data reduction.

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* One meter-Amagat corresponds to a column of gas of 1 m under standard conditions (1 atm. 273 °K).

Observations of a Supernova in NGC 4536 from La Silla

On March 2, 1981, the Soviet astronomer Tsvetkov at the Sternberg Astronomical Institute discovered a supernova in the Sc galaxy NGC 4536. Its photographic magnitude was 12.3 (IAU Circular No. 3580). It was one of the brightest supernovae in recent years; in fact it was so bright as to be easily observable with the International Ultraviolet Explorer, and Dr. N. Panagia, on behalf of the ESA-SRC team for SN observations urged the ESO staff on La Silla to make optical observations of this object. These observations have been organized by T. Danks.

A Schmidt plate of the field was taken on March 10 by Guido Pizarro (Fig. 1). M.-P. Véron was observing on the photoelectric 1 m telescope; she was able to obtain a UBV measurement on March 12 (06.15 UT). The visual magnitude was then V = 11.93, which corresponds to an absolute magnitude $M_V = -20.66$ if the galactocentric radial velocity of the galaxy is 1646 km s^{-1} (Sandage and Tammann 1981, a revised Shapley-Ames catalogue of bright galaxies) and H_O = 50 km s^{-1} Mpc^{-1}. This seems to be exceptionally bright, even for a type I supernova (IAU Circular No. 3584). Subsequent measurements by T. Danks have shown that 3 weeks later, the brightness of the supernova had decreased by a full magnitude (V = 12.90 on April 1, V = 13.09 on April 4).

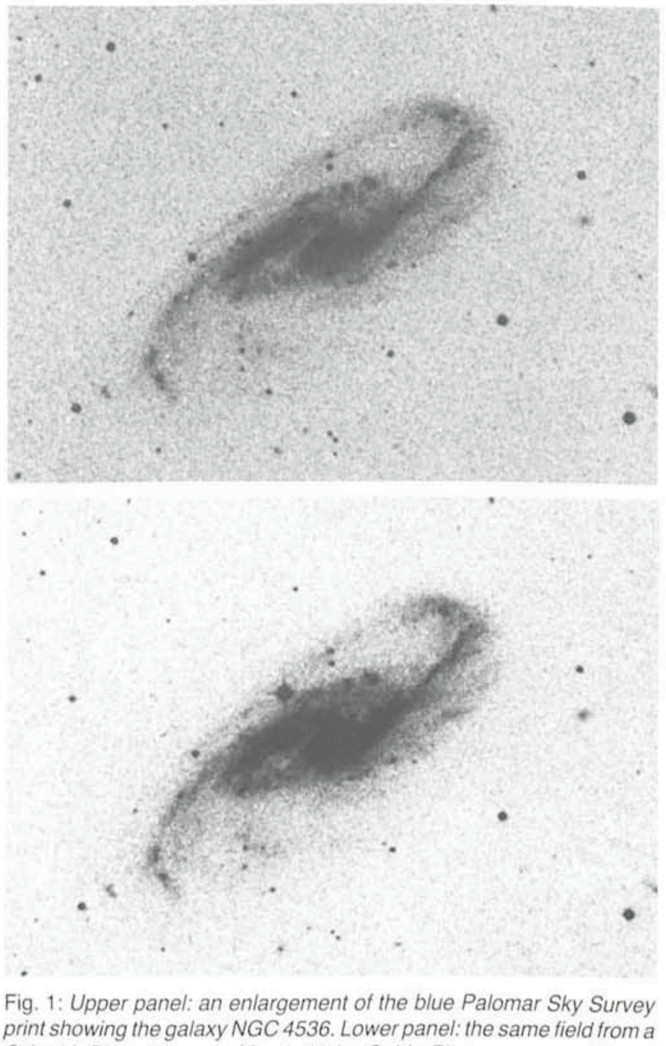

Fig. 1: *Upper panel: an enlargement of the blue Palomar Sky Survey print showing the galaxy NGC 4536. Lower panel: the same field from a Schmidt Plate taken on March 10 by Guido Pizarro on an unfiltered IIa-O emulsion. The exposure time was 30 minutes. The supernova is clearly seen NE of the nucleus.*

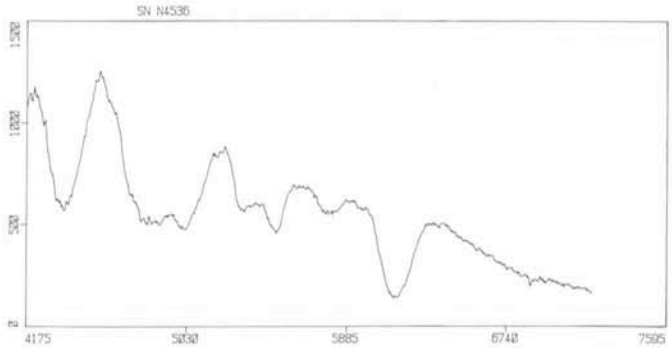

Fig. 2: *Spectrum of the supernova obtained on March 13 with the Boller and Chivens spectrograph attached to the ESO 1.5 m telescope. The vertical scale is in units of 10^{-16} erg s^{-1} cm^{-2} $Å^{-1}$; the horizontal scale in Ångströms.*

Spectra have been obtained by M.-P. Véron and P. Véron on four consecutive nights (March 11, 12, 13 and 14) with the Boller an Chivens spectrograph and the IDS attached to the 1.5 m telescope. The dispersion was 171 Å/mm and the resolution about 10 Å. One of these spectra is shown in Fig. 2. They show broad emission features at wavelengths 4614, 5202, 5669 and 6346 Å (IAU Circular No. 3584).

P. Salinari from the Astrophysical Observatory in Arcetri and A. Moorwood have made infrared measurements in the J (1.25 μm), H (1.65 μm) and K (2.20 μm) bands, with the 3.6 m telescope on the nights of March 17 and 22. They have noted a larger decay in the J band ($\triangle J$ = 0.82 mag) than in the two others in this 5-day interval (IAU Circular No. 3587).

It is hoped that these observations, together with the IUE observations made on March 9, 10 and 11 (IAU Circular No. 3584) and the many others made throughout the world will help understanding better these objects.

P. V.

ALGUNOS RESUMENES

La inauguración de la sede de ESO en Garching

Durante varios años los departamentos europeos de ESO se encontraban ubicados en parte en Ginebra y en parte en Hamburgo. Esta separación de la organización hacía difícil su administración. Hace aproximadamente cinco años el gobierno alemán ofreció la construcción de un edificio para la ESO en el campus de la Sociedad de Max Planck en Garching cerca de Munich. El departamento de administración se trasladó inmediatamente desde Hamburgo a oficinas provisorias en Garching, y una vez terminada la construcción del edificio, hace alrededor de seis meses, el centro europeo de ESO encontró su hogar definitivo.

El día martes 5 de mayo de 1981 se llevó a efecto la inauguración de la nueva sede con la presencia del Presidente de la República Federal de Alemania, Karl Carstens. A la ceremonia asistieron más de 200 invitados, representantes diplomáticos, administradores y científicos de ESO y otros países, inclusive Italia y Suiza; se espera que estos dos últimos países formarán parte de la Organización dentro de algunos meses.

La ceremonia fue abierta por el Prof. L. Woltjer, Director General de la ESO, quien dio la bienvenida a los invitados. Otros oradores fueron – en orden cronológico –: Prof. R. Lüst, Presidente de la Sociedad Max Planck, E. Stahl, Secretario Parlamentario del Estado del Ministerio Federal para la Investigación y Tecnología, Dr. F. J. Strauss, Primer Ministro del Estado Libre de Bavaria, y Prof. J.-F. Denisse, Presidente del Consejo de ESO.

Después de la ceremonia de inauguración el Presidente de la República Federal de Alemania ofreció un almuerzo en el cual él dio un discurso dando la bienvenida a ESO, a sus colaboradores y a sus familiares en Alemania. Le agradeció el Prof. Denisse.

Al atardecer el Gobierno del Estado de Bavaria ofreció una recepción a los participantes y sus cónyuges.

La tarde y el día siguiente fueron dedicados a un symposium sobre «La Evolución del Universo».

A pesar del pésimo tiempo que reinó durante el primer día los participantes quedaron maravillados con la perfecta organización de estos eventos y se despidieron de Munich con la impresión de que ahora ESO es una organización madura y eficiente.

Los primeros pasos de ESO

En 1953 se sostuvieron ya las primeras conversaciones sobre la creación de un observatorio europeo austral. A éstas le siguieron varias reuniones informales, y aproximadamente 9 años más tarde, el día 5 de octubre de 1962, cinco de los actuales seis países miembros firmaron la Convención de ESO. Más tarde, en 1967, se integró Dinamarca a la Organización.

En un comienzo la búsqueda de un sitio adecuado fue concentrada en Sudáfrica, y la atención de ESO fue atraída hacia Chile sólo en el momento cuando AURA decidió construir un observatorio en Chile, cerca de La Serena (Tololo).

En 1963 se comenzaron los estudios del terreno en La Silla y los resultados demostraron que la ubicación era realmente superior a los lugares vistos en Sudáfrica. En noviembre de 1963 se firmó una Convención con el Gobierno de Chile.

Con el fin de dar rápidamente una efectiva vida científica al observatorio se decidió construir tres telescopios de tamaño intermedio: el telescopio Schmidt de 1 m, y los telescopios espectrográfico de 1,5 m y fotométrico de 1 m.

La concepción y la construcción del telescopio de 3,6 m fue confrontada con muchas dificultades, y con el fin de superar estos problemas se firmó un contrato entre ESO y CERN en Ginebra que permitió formar una división de Proyecto de Telescopio en el recinto de CERN. Esta eficaz ayuda posibilitó obtener finalmente el telescopio de 3,6 m que comenzó a operar a fines de 1976.

Pero también el esparcimiento de los diversos servicios causaron problemas: en Europa – Hamburgo y Ginebra, y en Chile – Santiago, La Serena y además La Silla. Particularmente los tres centros en Chile fueron causa de eternos viajes entre la montaña, La Serena y Santiago.

Ahora estas circumstancias ya no valen. La Silla es el corazón de ESO, y el traslado desde Ginebra a Munich, siendo centro europeo, ciertamente traerá beneficios.

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 six countries: Belgium, Denmark, France, the Federal Republik of Germany, the Netherlands and Sweden. It now operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where ten telescopes with apertures up to 3.6 m are presently in operation. The astronomical observations on La Silla are carried out by visiting astronomers – mainly from the member countries – and, to some extent, by ESO staff astronomers, often in collaboration with the former.

The ESO Headquarters in Europe are located in Garching, near Munich.

ESO has about 120 international staff members in Europe and Chile and about 150 local staff members in Santiago and on La Silla. In addition, there are a number of fellows and scientific associates.

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Editor: Philippe Véron
Technical editor: Kurt Kjär

EUROPEAN
SOUTHERN OBSERVATORY
Karl-Schwarzschild-Str. 2
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Fed. Rep. of Germany
Tel. (089) 320 06-0
Telex 05-28 282-0 es d

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