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Otto Heckmann

1901–1983

Otto Heckmann, past Director General of the European Southern Observatory (1962–1969), President of the International Astronomical Union (1967–1970), and the Astronomische Gesellschaft (1952–1957), Professor of Astronomy and Director of the Hamburg Observatory (1941–1962), died on May 13, 1983.

Prof. Otto Heckmann

Photograph: Dr. Peter Lamersdorf

The European Southern Observatory has particular reason to be grateful to Otto Heckmann whose creative impulse was the essential contribution to the final realization of this European organization.

Born on June 23, 1901 in Opladen, he early developed his interest in astronomical problems. F. Küstner at the University of Bonn introduced him into classical positional astronomy. He very probably formed his scientific style. After having received his Ph. D. at Bonn, however, he soon followed an invitation by H. Kienle to Göttingen, where he became acquainted with modern astrophysical problems.

As an excellent observer he soon could improve the accuracy of photographic photometry to a hitherto unequalled level. Famous were his investigations on the colour-magnitude diagram of open clusters, together with H. Haffner.

Fascinated by E. Hubble's discovery of the redshift-distance relation of extragalactic nebulae in 1929, he resumed earlier investigations on cosmology which finally resulted in the publication of his book, *Theorien der Kosmologie* which later appeared at Hamburg in 1942.

Whoever witnessed the period of intellectual suppression in the late thirties in Germany, can imagine the hazardous enterprise of such a publication at that time.

In 1941 Otto Heckmann received his appointment as the Director of the Hamburg Observatory. First engaged in the accomplishment of the great astronomical catalogues AGK 2 and AGK 3, he soon went into the foot prints of Walter Baade who once had built a large Schmidt telescope. The inauguration of the "Hamburg Big Schmidt" was the initiative step towards a greater task.

Otto Heckmann always kept close contact with Walter Baade. The latter, giving lectures at the Leiden Observatory, in 1953 emphasized to the European astronomers the great importance of a common European observatory "established in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organizing collaboration in astronomy".

In a fundamental conference with W. Baade in the spring of that year, a number of outstanding European astronomers, among whom A. Danjon from France, P. Bourgeois from Belgium, J. H. Oort from the Netherlands, Sir Harald Spencer-Jones from Great Britain, B. Lindblad from Sweden, O. Heckmann from Germany, decided to realize this project. In the following years, however, it was always Otto Heckmann who pushed things forward, who initiated hope and trust when despondency and depression threatened the success of the plan.

It was again Otto Heckmann who in 1962 after his appointment as Director General and until his retirement in 1969 carried all the burden of the immense task of building up the headquarters of ESO, and the observatory on La Silla in Chile, and to bring it finally into operation.

With Otto Heckmann an outstanding astronomer is gone, honoured by the award to him of the degrees of Dr. h.c. of the University of Aix-Marseille in 1966, Dr. h.c. of the University of La Plata in 1968, and Hon. D.Sc. of the University of Sussex in 1970, by the membership in numerous Scientific Academies of Europe and the Americas, and many gold medals of which as an example only the Bruce Medal of the Astronomical Society of the Pacific will be mentioned.

A. Behr

The ESO Echelle Spectrograph for the Cassegrain Focus of the 3.6 m Telescope

S. D'Odorico, D. Enard, J.L. Lizon, B. Ljung, W. Nees, D. Ponz, G. Raffi and J.F. Tanne, ESO

In the first tests at La Silla, CASPEC, coupled with a CCD detector, proved to be a promising instrument for high dispersion work on faint objects.

A Brief History of CASPEC

The decision to build a cross dispersion Cassegrain echelle spectrograph for the 3.6 m telescope can be traced back to 1974. However, the load of work to complete the 3.6 m telescope was such that only in 1976 Maurice Le Luyer could present the first optical concept. With the collaboration of a review team composed of J. Andersen, L. Delbouille, E. Maurice, P. E. Nissen and several ESO astronomers (P. Crane, J. Danziger, J. Melnick and M. H. Ulrich) a final design was adopted in June 1978. Then the detailed engineering phase took off: M. Le Luyer was appointed project leader and in charge of the optics; W. Richter designed the mechanics and the structure, and W. Nees and P. Schabel took the responsibility of the instrument control and its detector. The latter was initially thought to be a SEC vidicon.

When, in the summer of 1980, ESO moved into its new headquarters in Munich, CASPEC's construction was well advanced, but many of the staff members who were involved in the project left ESO. This resulted in a delay of more than a year: only in October 1981 could J. F. Tanne, a new staff member at the time, be appointed technical project leader with the task of finally assembling and testing the mechanical and optical components. In this he was helped by J. L. Lizon, while G. Raffi coordinated the instrument software, and D. Ponz started to work on a data reduction package. S. D'Odorico took care of the astronomical requirements and the preparation of the test programme.

At the end of 1982 it was realized that the VIDICON was not performing as well as expected, due mainly to problems with the magnet coils. It was then decided to switch to a CCD, which had been routinely used in direct imaging at La Silla for some time, as the spectrograph detector.

In the tests at the 3.6 m telescope in June and July 1983, CASPEC performed exceptionally smoothly and without problems for a complex instrument used for the first time at the telescope. Some minor hardware and software problems were detected and will be solved before the instrument comes into routine operation. Resolution, stability and speed proved to be very close to the predicted values.

Although the reduction and detailed evaluation of the more than one hundred useful astronomical images has just started, we report preliminarily on the instrument, to give some guidelines to the astronomers who want to apply for the next observing period.

A detailed technical report and a user's manual will be available to the users by the beginning oft next year.

The Present Instrument Configuration and Mode of Operation

The Optical Layout

The optical design and the parameters of the main optical components of CASPEC have been presented in the *Messenger* No. 17 and will not be repeated here. The configuration in which the instrument will be offered initially to the users is determined mainly by the small size of the present CCD, which is a 512 × 320 pixels, 15.36 × 9.6 mm back illuminated RCA chip. The combination of a 31.6 lines/mm echelle (blaze angle = $63\overset{\circ}{.}4$) and a 300 lines/mm cross dispersion grating (actually a mosaic of two), and the short camera (achromatic and of the folded Schmidt type, F = 1.5) gives a compact format in which about 900 Å, split into several orders, are recorded in one frame.

At 5000 Å, the reciprocal dispersion is 5 Å/mm with a resolving power of 20000. At the Cassegrain focus of the 3.6 m telescope, 1.2 and 0.74 arcsec are projected on one pixel of the detector in the direction of the dispersion and perpendicular to it respectively.

CASPEC can be used in the range 3500–10000 Å; the different wavelength regions are centred on the CCD by moving the cross disperser. The echelle grating position is kept fixed. Spacing between the orders varies from more than 50 pixels in the extreme red to as little as 5 in the extreme blue. These values and the need for a free interorder spacing in the CCD to monitor the background define the limits of the two-dimensional capability of CASPEC. For example, at H_α, a 20 arcsec slit can be used while still keeping the orders well separated. A thorium lamp is used for the comparison spectrum and a built-in quartz lamp for the flat field. In both cases the exposure times are of a few seconds. The stability of the instrument, which represented a major problem in the first tests in Garching, is now better than 1 pixel over 90° of rotation.

Function Control and Operating Software

All CASPEC functions, 15 in total, are remotely controlled from the console at the user station. A new modular design approach was conceived for the functions (like, e.g., collimator, slit, and cross disperser) which have to vary within a given range. They are performed by closed-loop positioning systems, all of which incorporate the following items: D. C. motor, tacho, absolute-position encoder, motor-drive amplifier, encoder position decoding module and a microprocessor controller. As a result most of the individual functions at the spectrograph are interchangeable among each other and the total number of spare components could be minimized. The microcontrollers are new ESO standard CAMAC modules especially developed for control applications.

The CASPEC on-line software, to control the instrument, acquires data from the CCD detector and to do on-line data reduction, consists of quite a number of programmes cooperating together. It runs under the RTE-4B operating system in an ESO standard HP 1000 configuration (256 Kw of memory, 50 Mbytes disk, CAMAC crate). The main programme (CASP) handles the user interface and the instrument logic. A software package sets up and monitors the CCD detector via a microprocessor controller. It executes exposures on demand and stores acquired data on disk and tape. The IHAP data processing system is used for on-line data reduction and now includes a command for extraction of an order from the two-dimensional echelle format.

The user input is via function keys and forms, which have to be filled in with the appropriate parameters. The format is such that a visiting astronomer should quickly learn how to set up a single exposure or a sequence of exposures.

The CASPEC programmes make use of a new data acquisition system (called DAQ) developed at ESO to easily transfer detector packages (like that of the CCD) to various instruments and instrument packages to different telescopes. CASPEC is the first instrument developed within this new frame but the software for the new B & C spectrograph for the 2.2 m telescope and for EFOCS, the faint object spectrograph for the 3.6 m are being implemented now along the same lines.

The Bright and Dark Sides of the CCD

The performance of the CCD chip which is currently used at CASPEC is in general quite satisfactory. The read-out noise is 40 e^-/pixel, the dark current 15 e^-/hour/pixel at T = 150°K. The quantum efficiency peaks at λ5000 with 60 % and is 15 % and 25 % at 3500 Å and 9000 Å respectively. These values were measured on the detector test bench in Garching. There the CCD was also found to be linear within 0.1 %.

On the dark side, this CCD shows a degraded horizontal charge transfer when a spectral image is formed on a dark background. This results, e.g., in a low amplitude tail at the right side of a comparison spectrum line. This effect can be eliminated by exposing the chip uniformly to a low level of light, at the price, however, of introducing additional noise to the image. In the present configuration the effect is perpendicular to the dispersion direction. Two hot areas, whose intensities increase linearly with time, are also observed on the border of the CCD. The charge spread which they produce is not severe for exposure times up to two hours. More annoying are the randomly distributed, non-reproducible spikes whose number rises with exposure time at a rate of about 2/minute. The only possible explanation are cosmic rays, but their frequency is about twice that quoted in the literature.

The most severe problem of the CCD remains however that of the "fringes" which are produced by light interference within the chip and result in a reduction of the sensitivity at a given wavelength and position. For this chip, they are as high as 30 % in the red. In the scarce literature on spectroscopic use of the CCDs which is available, it is stated that they can be accurately flat-fielded. In our case, the process is made more complicated by the existence of a background of bias and scattered light which has to be subtracted before the star spectrum is divided by the flat field image from the quartz lamp. When these problems are taken into account, our preliminary reductions indicate that an accuracy of at least 1 % can be achieved in the flat-field correction.

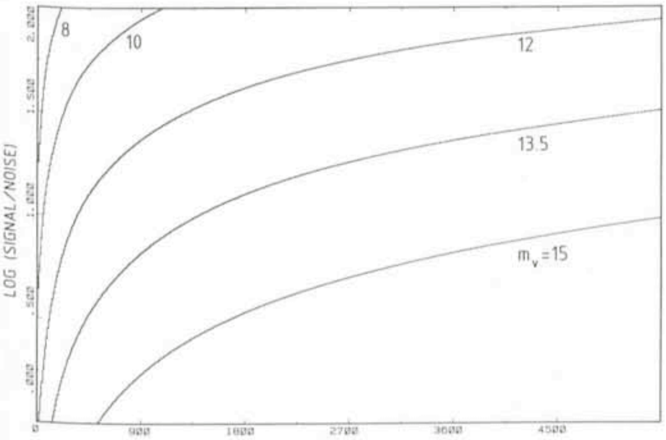

Fig. 1: *The predictions for signal/noise ratios as a function of exposure time for stars of different magnitudes at λ5000 Å. Photon statistics and the read-out noise of the CCD (50 electrons) were considered as sources of noise. These predictions were made a few months before the test observations. They were found to provide useful guidelines for the actual observations under very good seeing conditions (FWHI ≤ 1 arcsec). With larger images, both the loss of light and the spread over more pixels perpendicular to the dispersion partially degrade the S/N of the observations.*

Tentative Time-table of Council Sessions and Committee Meetings Until December 1983

November 8	Scientific and Technical Committee
November 9–10	Finance Committee
November 11	Committee of Council
November 29–30	Observing Programmes Committee
December 1–2	Council

All meetings will take place at ESO in Garching.

The First Astronomical Results

The test observations indicate that the main goal of the CASPEC project, i.e. relatively high dispersion spectroscopy on faint objects, has been achieved. Fig. 1 can be used as a guideline for limiting magnitudes, and S/N ratios. Observations at good signal to noise of the continuum of objects as faint as m_v = 14 have easily been achieved with average seeing conditions. Emission lines have been observed in objects of fainter magnitudes. Fig. 2 shows one such observation. CASPEC definitely gives new possibilities to European astronomers and its capabilities appear rather good when compared with the performances of similar instruments, such as the Kitt Peak or MMT echelle spectrographs. The programmes which become feasible cover quite different topics in astrophysics. One can mention the study of interstellar lines in the Magellanic Clouds stars, the determination of abundances of stars in globular clusters and in the halo, the study of the velocity profiles in emission line galaxies, stars, quasars and supernova remnants, but this list is obviously incomplete.

While a large amount of original work can certainly be done with the present instrument configuration, one has also to be aware of its limitations. Fig. 3 shows that the higher resolution of the CAT + CES combination is worth being used when one

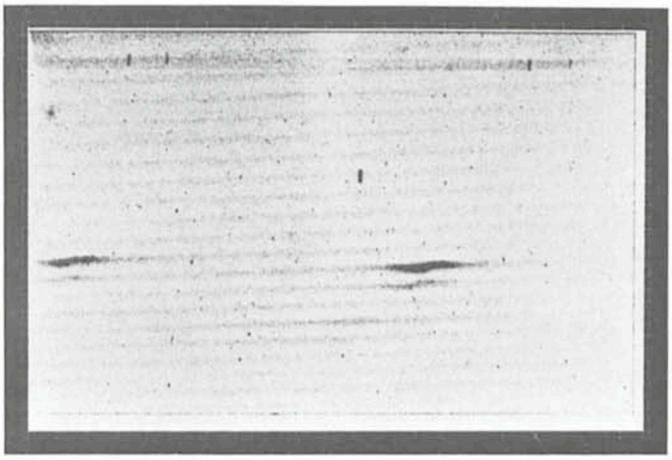

Fig. 2: *A 130-minute CASPEC exposure of the approximately 14th magnitude quasar MR 2251–178. The entrance aperture measured 2.1 × 5 arcsec on the sky. The H_β and [OIII] $\lambda\lambda$ 4959, 5007 lines (well visible in two different orders) as well as the narrow λ 5577, λ 5890–96 Å sky lines are present in the spectrum.*

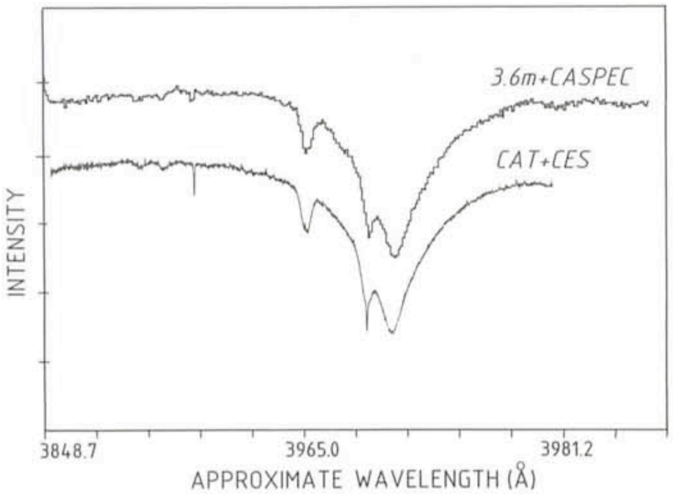

Fig. 3: *This figure, which shows the interstellar H line of CA II in the star HR 5358 (m_B = 4.4) as observed on the same night with the CAT + CES and with the 3.6 m + CASPEC, permits an interesting comparison. Parameters of the first observation are as follows: R = 100000, slit width = 1.1 arcsec, exposure time 20 min., spectral coverage = 33 Å. For CASPEC: R = 20000, slit width = 1.2 arcsec, exposure time = 1 min., spectral coverage = 1000 Å. The CES observation is a courtesy of Dr. I. K. Furenlid.*

is not limited by the number of photons or when one does not require a wide spectral coverage. Another point worth noting is that the compactness of the present format limits the use of the two-dimensional capabilities and makes the data reduction problems harder below λ4500 Å. It is hoped that these problems will be solved in the future by the introduction of a large detector. In the meantime, a limited amount of compromise is possible between different requirements. As an example, if the echelle grating with 79 lines/mm is used, the spacing between the orders is doubled but the merged spectrum presents gaps in its wavelength coverage above 4000 Å. We envisage that the possible modifications of the present set-up will depend on the desiderata of the users and on the experience gathered in the first months of operation.

There are a few points of the present mode of operation which are worth mentioning to help the planning of the observations. One is the upper limit for the exposure time. The spread of the hot areas and the spatial frequency of spikes in the CCD suggests limiting the exposures to something like 2 hours. Since these cosmetic defects can be removed at least partially in the data processing phase, the decision depends somewhat on the scientific goals of the observer.

In the test observations the sky was visible on the spectra only in long exposures within 90 degrees of the full moon. In any case it is a sensible procedure to monitor the background by using a long slit wherever this is permitted by the spacing

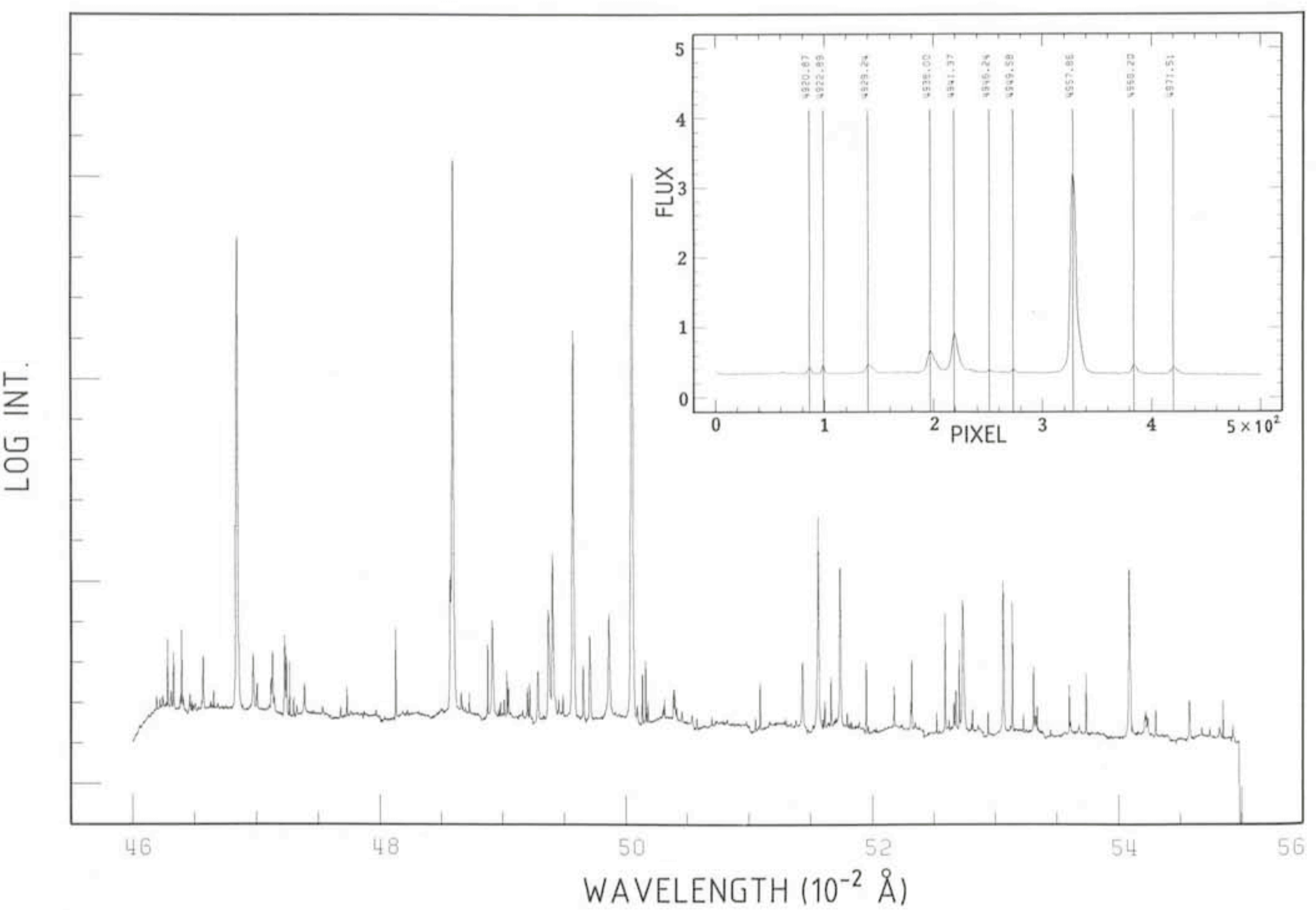

Fig. 4: *23 wavelength-calibrated and merged orders from a CASPEC CCD frame of the slow nova RR Tel centred at λ = 5000 Å. The exposure time was 8 minutes. The positions of the orders were automatically identified using the corresponding flat-field image. The wavelength calibration was obtained again automatically upon entering the screen position of a few lines of the comparison lamp image. The standard deviation, based on the position of 115 lines, was 0.05 Å. The line intensities have not been corrected for the instrumental response. The inset shows the automatically measured wavelengths of emission lines in one of the orders of the RR Tel image.*

between the orders. The CCD package allows binning of the pixels in the read-out process. This option finds useful application in an observation where the read-out of the CCD is the dominant noise source. Binning perpendicular to the dispersion can be advantageous in poor seeing conditions. In the present set-up however, it can be applied only at wavelengths above 5000 Å, to avoid an excessive crowding of the spectral orders. Binning in the direction of the dispersion, with the resulting loss of resolution, may also be an attractive solution in the observation of very faint sources or to follow with higher temporal frequency the spectral behaviour of brighter objects.

The Status of the Data Reduction Software

Astronomers who have used other ground-based echelle spectrographs or, e.g., the high dispersion mode of IUE, are familiar with the difficulties in the data reduction and calibration of spectra in echelle format. To these must be added, in the case of CASPEC, the problems specific to the CCD data reduction. ESO plans to have a full reduction package working by the end of 1983 on the VAX 11/780 computer within the framework of the data processing system MIDAS. The programme will run partly automatically, partly in interactive mode from a de Anza display station. It will flat-field the images, find and extract the spectral orders, set a wavelength calibration from the comparison lamp spectrum, merge and flux-calibrate the spectral orders. The user will then have the option to analyse further the one-dimensional files within MIDAS, to switch to IHAP or to perform the final steps of the data reduction at his home institution. The same package will be installed on the VAX computer at La Silla, to be used by the La Silla staff and off the telescope by visiting astronomers.

A large part of this package is already operational. Fig. 4 illustrates what can be achieved today as regards extraction, wavelength calibration and merging of the spectral orders in one CCD frame. At present we are using the test observations to optimize the procedure to flat-field and flux-calibrate the spectra.

A Word of Thanks

It is largely thanks to the excellent assistance of the La Silla staff that CASPEC's installation at the telescope was such a smooth and successful operation. We would also like to thank the other people who have contributed with their work or their advice in the different phases of this project, among them P. Biereichel for the CCD package, R. Gustafsson for the control modules, F. Middelburg for the updating of IHAP, J. Melnick for the data reduction, and the European astronomers who have provided useful suggestions for the programme of test observations. A particular acknowledgement goes to Prof. I. Appenzeller, who was actually present during part of the test period and was of great help in evaluating the instrument performances.

Visiting Astronomers

(October 1, 1983–April 1, 1984)

Observing time has now been allocated for period 32 (October 1, 1983–April 1, 1984). As usual, the demand for telescope time was much greater than the time actually available.

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

3.6 m Telescope

Oct. 1983: Dennefeld, Bergeron/Kunth, Bergeron/Boissé, Zuiderwijk/de Ruiter, Shaver/Robertson, Moorwood/Oliva, Oliva/Moorwood/Panagia, Moorwood/Glass, Lequeux/Prévot, L&ML/Maurice/Rocca, Perrier/Léna/Chelli/Sibille, Alcaíno/Liller, Materne/Hopp, Azzopardi.

Nov. 1983: Azzopardi, Azzopardi/Breysacher/Lequeux/Maeder/Westerlund, Surdej/Henry/Swings/Arp, Materne/Hopp, Azzopardi/Breysacher/Lequeux/Maeder/Westerlund, Westerlund/Azzopardi/Breysacher, Westerlund/Lundgren, Westerlund/Gustafsson/Graae Jörgensen, Pakull/Beuermann/Motch/Ilovaisky/Henrichs/van Paradijs, Koornneef/Israel, Israel/Koornneef, Rouan/Leger, van Paradijs/Motch/Beuermann/Zuiderwijk, Lindblad/Jörsäter.

Dec. 1983: Lindblad/Jörsäter, Bertola/Zeilinger, Capaccioli, Olofsson/Bergvall/Ekman, Sherwood/Moffat, Epchtein/Braz, Durret/Boisson/Lawrence, Caplan/Deharveng/Comte/Viallefond, Marano/Braccesi/Zitelli/Zamorani.

Jan. 1984: Marano/Braccesi/Zitelli/Zamorani, de Vries, Barbieri/Cristiani/Nardon, Jörgensen/Hansen/Nörgaard-Nielsen, Danziger/de Ruiter/Kunth/Lub/Maccacaro/Gioia, Kunth.

Feb. 1984: Kunth, Mouchet/Motch/Beuermann/van Paradijs, Motch/Ilovaisky/Pakull, Courvoisier, Schoembs/Barwig/Vogt/Koester/Kudritzki, Reimers/Koester, Koester/Weidemann, Weigelt/Drechsler, Véron.

March 1984: Véron, Bettoni/Galletta, Galletta/Bettoni, Chincarini/Manousoyannaki, de Jong/Miley, de Loore/Burger/v. Dessel/v. Paradijs, de Jong/Miley, Thé/Lamers, Krautter, Engels/Perrier, Motch/Mouchet, Rodono/Catalano/Blanco/Marilli/Pazzani/Russo/Vittone/Butler/Scaltriti/Linsky/Foing.

1.4 m CAT

Oct. 1983: Kollatschny/Yorke/Fricke, Cayrel de Strobel, Gondoin/Mangeney/Praderie, Burkhart/Lunel/Van't Veer/Coupry.

Nov. 1983: Burkhart/Lunel/Van't Veer/Coupry, Barbuy, Grewin/Kappelmann/Bianchi, Seitter/Duerbeck, Kohoutek/Wehmeyer, Gustafsson/Andersen/Nissen.

Dec. 1983: Gustafsson/Andersen/Nissen, Eriksen, Ardeberg/Lindgren/Maurice, Danks/Lambert, Kudritzki/Gehren/Simon, Noci/Ortolani.

Jan. 1984: Noci/Ortolani, Westerlund/Krelowski, Drechsel/Rahe/Wargau, Reimers/Hempe, Gillet/Faurobert.

Feb. 1984: Gillet/Faurobert, Viotti/Altamore/Rossi, Gry/Ferlet/Vidal-Madjar, Ferlet/Roueff, Kudritzki/Nissen/Gehren/Simon, Baade.

March 1984: Baade, Felenbok/Roueff/Praderie/Catala/Czarny, Grewin/Krämer/Gutekunst/Bianchi, Foing/Bonnet/Linsky/Walter, Foing/Bonnet/Linsky/Bornmann/Haisch/Rodono.

1.5 m Spectrographic Telescope

Oct. 1983: Rafanelli/Bonoli, Pelat/Nottale, Schiffer, Prévot, L./Lequeux/Prévot, M. L./Maurice/Rocca, Richter/Sadler, Chincarini.

Nov. 1983: Chincarini, Crane/Chincarini/Tarenghi, Ardeberg/Lindgren, Bues/Rupprecht, Danziger/Maraschi/Tanzi/Treves, Viotti/Gilmozzi/Wolf/Zickgraf, van Paradijs/Motch/Beuermann/Zuiderwijk, Olofsson/Bergvall/Ekman.

Dec. 1983: Olofsson/Bergvall/Ekman, Kohoutek/Wehmeyer, Lub/de Ruiter, Capaccioli, Reipurth, Rosa.

Jan. 1984: Rosa, Bica/Alloin, Chmielewski/Jousson, Wolf/Appenzeller/Klare/Leitherer/Stahl/Zickgraf/Bastian, Lindblad/Lodén, Molaro/Franco/Morossi/Ramella, Joubert, Georgelin/Boulesteix/Marcelin/Rosado.

Feb. 1984: Georgelin/Boulesteix/Marcelin/Rosado, Schulte-Ladbek, de Loore/van Paradijs/Zuiderwijk, Zuiderwijk/van Paradijs/de Loore, Foing/Bonnet/Linsky/Bornmann/Haisch/Rodono, Maurice/Louise, Chincarini/Manoussoyannaki.

March 1984: Chincarini/Manoussoyannaki, Festou/Dennefeld, Bettoni/Galletta, Melnick/Quintana/Terlevich, Andersen, Thé/Lamers, Jensen, Festou/Dennefeld, Brand/Wouterloot, Festou/Dennefeld, Krautter, Maurice/Louise, Festou/Dennefeld.

1 m Photometric Telescope

Oct. 1983: Lauberts, Krügel/Chini, Perrier/Léna/Chelli/Sibille, Oliva/Moorwood, Arp/Gosset/Surdej/Swings.

Nov. 1983: Arp/Gosset/Surdej/Swings, Prévot, M. L./Prévot, L./Lequeux/Maurice/Rocca, Arp/Gosset/Surdej/Swings, Bues/Rupprecht, Pakull/Beuermann/Motch/Ilovaisky/Henrichs/van Paradijs, van Paradijs/Motch/Beuermann/Zuiderwijk, Cristiani.

Dec. 1983: Cristiani, Olofsson/Bergvall/Ekman, Fricke/Biermann/Colina, Reipurth, Lindroos, Bica/Alloin/Dottori/Pastoriza.

Jan. 1984: Bica/Alloin/Dottori/Pastoriza, Barbieri/Nardon/Cristiani, Souza/Chincarini, Wolf/Appenzeller/Klare/Leitherer/Stahl/Zickgraf/Bastian, Wargau/Drechsel/Rahe, Encrenaz, Schoembs/Barwig/Vogt/Koester/Kudritzki.

Feb. 1984: Schoembs/Barwig/Vogt/Koester/Kudritzki, Bouvier/Bertout, Maitzen/Catalano, Cetty-Véron, Lagerkvist/Rickmann.

March 1984: Lagerkvist/Rickman, Westerlund/Thé, Thé/Lamers, Engels, Encrenaz, Krautter, Rodono/Catalano/Marilli/Blanco/Pazzani/Russo/Vittone/Scaltriti/Butler/Linsky/Foing, Brand/Wouterloot.

50 cm ESO Photometric Telescope

Oct. 1983: Pedersen/Danziger/Brinkmann/Kanbach/Reppin/Rieger/Trümper/Hurley/Lund/Ilovaisky/Motch/Pizzichini.

Nov. 1983: Pedersen/Danziger/Brinkmann/Kanbach/Reppin/Rieger/Trümper/Hurley/Lund/Ilovaisky/Motch/Pizzichini.

Dec. 1983: Pedersen/Danziger/Brinkmann/Kanbach/Reppin/Rieger/Trümper/Hurley/Lund/Ilovaisky/Motch/Pizzichini.

Jan. 1984: Pedersen/Danziger/Brinkmann/Kanbach/Reppin/Rieger/Trümper/Hurley/Lund/Ilovaisky/Motch/Pizzichini.

Feb. 1984: Pedersen/Danziger/Brinkmann/Kanbach/Reppin/Rieger/Trümper/Hurley/Lund/Ilovaisky/Motch/Pizzichini, Foing/Bonnet/Linsky/Bornmann/Haisch/Rodono.

March 1984: Foing/Bonnet/Linsky/Bornmann/Haisch/Rodono, Westerlund/Thé, Lagerkvist/Richman, Baade, Foing/Bonnet/Linksy/Bornmann/Haisch/Rodono.

GPO 40 cm Astrograph

Nov. 1983: Valbousquet/Florsch.

Dec. 1983: Valbousquet/Florsch.

Jan. 1984: Amieux.

Feb. 1984: Amieux, Debehogne/Lagerkvist/Machado/Caldeira/Netto/Vieira/Mourao/Tavares/Nunes/Bezerra/Zappala/de Sanctis/Protitch-Benishek.

March 1984: Debehogne/Lagerkvist/Machado/Caldeira/Netto/Vieira/Mourao/Tavares/Nunes/Bezerra/Zappala/de Sanctis/Protitch-Benishek.

1.5 m Danish Telescope

Oct. 1983: Maurice, Andersen/Nordström/Olsen, Prévot, L./Imbert/Andersen/Nordström/Mayor/Ardeberg/Lindgren/Maurice, Imbert/Prévot, L./Andersen/Nordström/Ardeberg/Maurice/Mayor, Lindgren, Ardeberg.

Nov. 1983: Maurice, Andersen/Nordström/Olsen, Prévot, L./Imbert/Andersen/Nordström/Mayor/Ardeberg/Lindgren/Maurice, Imbert/Prévot, L./Andersen/Nordström/Ardeberg/Maurice/Mayor, Lindgren, Ardeberg, Ulrich/van Breugel/Miley/Heckman, Loose/Colina/Thuan, Grosbøl.

Dec. 1983: Durret/Bergeron, Pedersen, Quintana.

Jan. 1984: Quintana, Stahl/Wolf/Zickgraf, Liller/Alcaíno, Ardeberg/Lindgren.

Feb. 1984: Mayor/Burki.

March 1984: Mayor/Burki, Mayor/Mermilliod, de Loore/Burger/v. Dessel/v. Paradijs, Motch/Mouchet, Grewing/Krämer/Gutekunst/Bianchi, Sadler.

90 cm Dutch Telescope

Nov. 1983: Pakull/Beuermann/Motch/Ilovaisky/Henrichs/van Paradijs.

Dec. 1983: Schneider/Weiss/Rakos, Greve/van Genderen.

Jan. 1984: Greve/van Genderen, de Zeeuw/Lub/Lemstra/Blaauw.

Feb. 1984: Cuypers, Nelles.

March 1984: Nelles.

61 cm Bochum Telescope

Nov. 1983: Bianchi/Grewing/Pakull, Kohoutek/Wehmeyer.

Dec. 1983: Kohoutek/Wehmeyer, Sterken Group.

Jan. 1984: Sterken Group, Wolf/Appenzeller/Klare/Leitherer/Stahl/Zickgraf/Bastian.

Applications for Observing Time at La Silla

Period 33 (April 1–October 1, 1984)

Please do not forget that your proposals should reach the Section Visiting Astronomers **before October 15, 1983.**

Pulsation of Ap Stars

W. W. Weiss, Institute for Astronomy, University of Hawaii and University of Vienna; Max-Kade Fellow
H. Schneider, University Observatory Göttingen

It has been known for many centuries that one can determine by simple means if a barrel of wine is full, half empty, or – horribile dictu – empty. One knocks against the wall and listens to the echo. Another example of the same technique, but less interesting for the *connaisseur en vin* is given by seismology. Seismographs distributed all over the globe register earthquakes and since they are differently located with respect to an earthquake centre the registrations look different. From a comparison of such registrations geologists have extracted most of our knowledge about the structure and composition of the terrestrial interior. Corresponding experiments were also planned and successfully executed on the Moon and on Mars. Stellar astronomers, however, are not in the lucky position of their colleagues who work in our solar system with the help of satellites. They are limited to stars which pulsate voluntarily. We will not discuss here the question why some groups of stars pulsate and others do not. We shall only mention that pulsating stars have at least one layer in their interior which does not absorb pulsational energy, as is the case for the rest of the star, but produces energy of variable amount and in phase with pulsation. This mechanism keeps the star pulsating as long as this (these) layer(s) exists. Due to stellar evolution, diffusion, magnetic fields, to name only some possible mechanisms, these layers can disappear or undergo substantial changes so that the energy losses due to pulsation cannot be compensated anymore. Damping will result and finally the star will become stable against pulsation.

Damped oscillations are observed sometimes in stars when considerable mass falls onto a stellar surface, coming for example from an accretion disk or from a nearby companion star. X-ray emission usually is the consequence and sometimes additional periodic light variations with a decreasing amplitude are observed – damped oscillations.

To make a long introduction short, the analysis of stellar pulsation is a powerful tool, although a very complex one, for investigating stellar structures. Pulsation is one of the very few mechanisms which allow us to check the validity of theories of stellar structure with direct measurements. On these grounds, astronomers working in the field of chemically peculiar stars of the upper main sequence (so-called Cp stars, stars with spectral type ranging from late B to early F, also known as Ap stars) were excited when news spread a few years ago that some Cp stars definitely pulsate. Periods between 6 to 15 minutes and amplitudes of a few thousandths of a magnitude were observed.

Photometric and spectroscopic instabilities on time scales of minutes up to a few hours have been reported occasionally since the time the group of Ap stars was formally established. Karl Rakosch was one of the first in this field with a publication from the Lowell Observatory in 1963. However, evidence was not convincing at that time. This situation improved when J. Percy, in 1973, started a survey for pulsation in some Ap stars, which later was followed by more extensive studies by D. Kurtz in South Africa and by W. Weiss and H. Schneider at ESO and currently at Mauna Kea Observatory in Hawaii.

Before we continue, we should probably briefly comment on the nature of the peculiarity of Cp stars. A more detailed discussion of the characteristics of this group can be found in another article in this journal (H.M. Maitzen and W.W. Weiss: 1977, *The Messenger*, No. 11, p. 18). Cp stars differ from normal stars of comparable temperature and gravity in an overabundance of Rare Earth elements, Strontium and Iron group elements, among others. Cp stars rotate abnormally slow, reveal a spotty element distribution in their atmosphere, and frequently have a measurable surface magnetic field.

Besides the commonly used grouping of Cp stars into Si stars, Cr-Eu-Sr stars, He-weak stars, to name only some of the subgroups, it seems to be possible to distinguish Cp stars also according to their pulsational characteristics.

Pulsationally Stable Cp Stars

The Cp stars of this group are stable against pulsation or at least have amplitudes which are undetectable by standard photometric techniques.

This group comprises the vast majority of Cp stars.

Low-harmonic Radially Pulsating Cp Stars

This group resembles the long known δ Scuti-type stars. But let us first comment a little bit on the technical terms. The simplest pulsation we can imagine is the radial mode. Like a balloon which is attached to a bicycle pump with a broken valve, the star grows larger and collapses periodically. Eddington found already in the early years of theoretical investigations of stellar interiors a simple first order approximation for the period of radially pulsating stars,

$$P = Q\,(M/M_{\odot})^{-1/2}(R/R_{\odot})^{3/2},$$

with Q being called the pulsation constant ($Q \sim 0.03$ for δ Scuti stars). The period essentially corresponds to the time a star needs to adjust to hydrostatic equilibrium. Periods between 1.5^h and 2^h can be expected for a main-sequence A-type star.

However, it is possible that pulsation modes can also be excited so that one or more shells at certain distances from the stellar core do not participate in periodic movements, in other words, where matter is at rest. These shells are called, in analogy to acoustics, *nodes*.

Depending on the number of nodes we speak of first, second, etc. harmonics (or overtones). The pulsation period decreases if a star is pulsating in a higher overtone. The period ratio between the fundamental and first harmonic for Cepheids is, for example, about 0.77. Model calculations show that the fundamental-mode solution is primarily determined by the properties of the star about 3/4 of its radius away from the core. This means that the period of the fundamental mode is determined primarily by conditions in the central regions where most of the mass is located. Interestingly, Ap stars differ from normal stars mostly just in the very outer parts of their envelope.

These considerations in mind, astronomers interested in the stability of Cp stars were testing primarily in the period range of 1 to 3 hours. And indeed, at least 4 stars with an Ap classification are known meanwhile to pulsate in a low harmonic radial mode. HD 4849 was discovered in 1978 by Weiss during one of the ESO surveys ($P = 1.2^h$) and HD 10088 ($P = 1.5^h$) in 1982 at the Mauna Kea Observatory. HD 3326 and HD 185139 were discovered in 1981/82 by Kurtz. HD 11503 (γ Ari), HD 108945 (21 Com) and HD 224801 were found earlier to be possible pulsating stars, but different observers do not agree on the

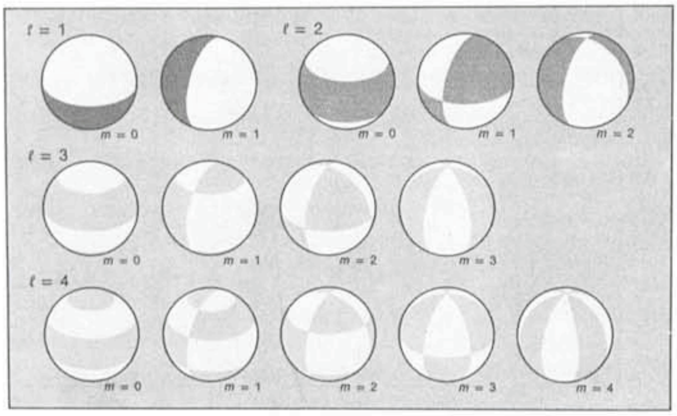

Fig. 1: *Non-radial pulsation modes (Winget and Van Horn,* Sky & Telescope, ***64,*** *216, 1982; by permission of the Sky Publishing Corporation).*

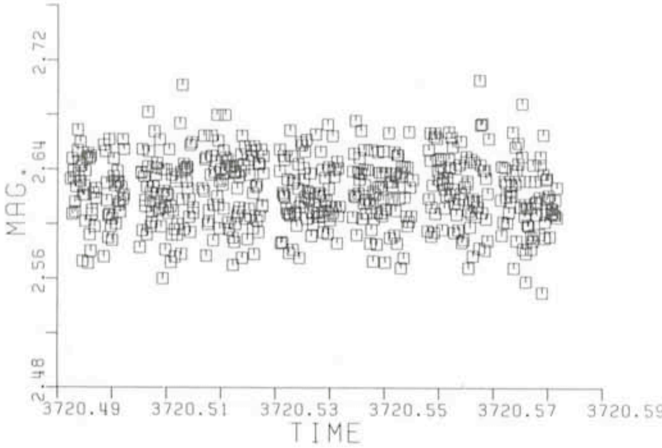

Fig. 2: *β photometry of HD 101065 (Weiss and Kreidl,* Astronomy and Astrophysics, ***81,*** *59, 1980).*

evidence of pulsation. For all the stars mentioned, there is a definite need for more detailed spectroscopic investigation. It has to be quantitatively established to what degree these stars are chemically peculiar, or if they are just extreme δ Scuti stars. Unfortunately, this group of variables populate the same temperature and gravity domain as do the pulsating Cp stars. More and better photometry is also required to determine the complete pulsation-frequency spectrum. The latter would allow a critical discussion of the pulsation modes.

High-harmonic, Non-radially Pulsating Cp Stars

In contrast to the δ Scuti-type pulsating Cp stars, the third group of Cp stars is better defined and their observed properties are well established. However, from the point of view of a theoretician they are even more difficult to understand.

But let us first clarify again some terms. Fig. 1 illustrates the situation for the lowest non-radial modes (l = 1 to 4). We see that not only nodal spheres are possible inside a star, but also nodal lines at the surface; i.e. regions which are at rest. The other non-radial mode parameter m characterizes the position of those nodal lines in the case of a star that is not completely centrally symmetric, but, for example, is rotating. The third integer parameter describing a non-radial mode is n and specifies the radial harmonics of the pulsation, similar to the already discussed case of radially overtone pulsation.

In fig. 1 areas which move in the same direction are shaded in the same tone. It becomes evident that non-radial modes can only be observed for distant stars (the sun is a special case), if l is a small number. Otherwise the light and radial velocity variations of different areas are cancelled or at least their observable effect is buried in the noise of the measurements.

In an interesting paper, D. Kurtz published the discovery of 12.2 min pulsations of HD 101065. This star is also called Przybylski's star since it was this astronomer who found extremely peculiar abundances for this star, making HD 101065 peculiar even in the group of peculiar stars. Kurtz interpreted the short period as a result of a non-radial ($l = 2$) high overtone ($n = 15$) mode. A few weeks after the announcement of Kurtz's discovery, W. Weiss had the opportunity of using the Danish Hβ photometer during some non-photometric nights and accumulated over 500 β values of Przybylski's star (fig. 2). Although HD 101065 is a faint object (B = 8.8 mag) considering the narrow filters and a 50 cm telescope, variations of the β index with a period of 12.5 minutes and an amplitude of 0.007 mag (fig. 3) could be detected, despite the poor signal-to-noise ratio. These observations clearly demonstrate the limits of the technique. The β amplitude together with the B and V measurements published by Kurtz cannot be interpreted as pure temperature variations. Additional gravity variations are required. The observations are therefore consistent with a pressure wave travelling through the atmosphere.

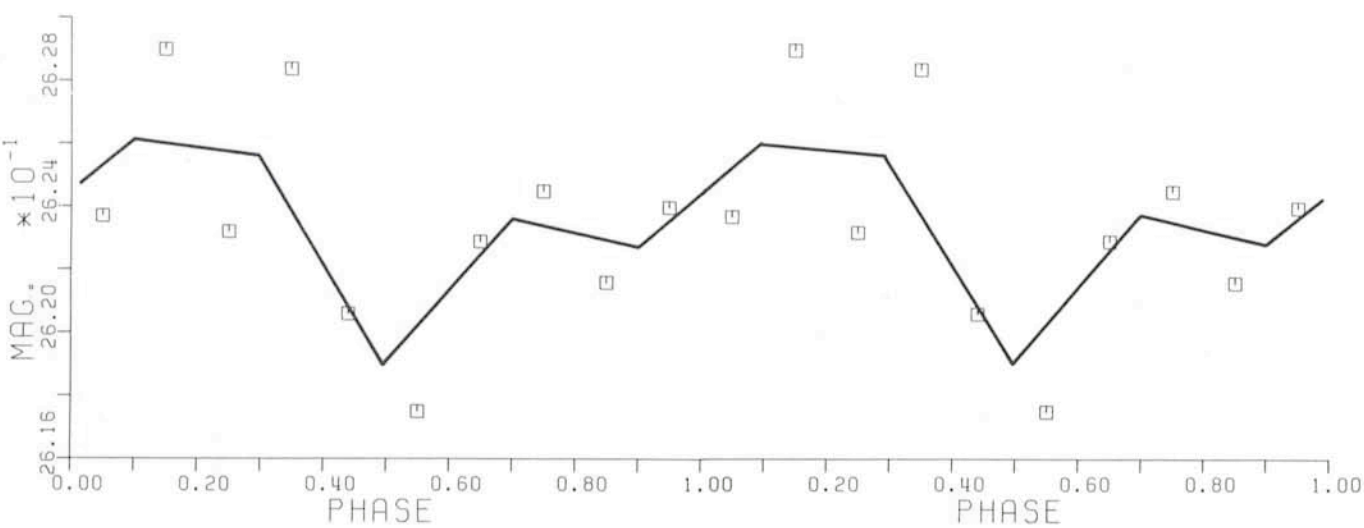

Fig. 3: *Light curve of HD 101065 in Hβ (Weiss and Kreidl,* Astronomy and Astrophysics. ***81,*** *59, 1980).*

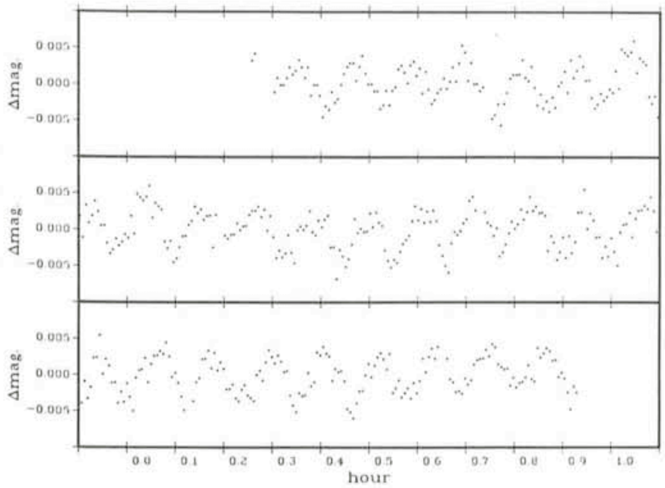

Fig. 4: *Pulsations of HD 128898 observed at La Silla with the 90 cm Dutch telescope, in the Walraven B band.*

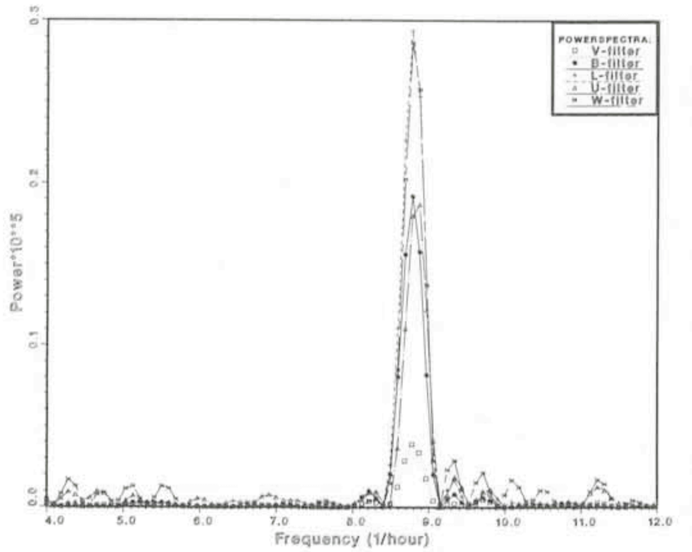

Fig. 5: *Power spectra for HD 128898 for all 5 Walraven colours.*

Another non-radially pulsating Ap star, also discovered by Kurtz, could be observed at ESO: HD 128898. The Walraven VBLUW photometer was used at the Dutch 90 cm telescope at La Silla. During an observing run of 24 nights in June 1982 we were lucky to observe HD 128898 during 3 of the total 20 clear hours of the entire run (it can be very depressing down there in Chile, sometimes!). We got excellent light curves in all colours and we present the B measurements in fig. 4. They are not typical, they are the best ones. A synopsis of the power spectra for all 5 colours is given in fig. 5. The light amplitudes are clearly a function of the wavelengths and we observed the same frequency in all five channels – as expected. Currently we are preparing a paper on these data which hopefully will allow us to specify the mode of pulsation by comparing theoretically determined phase-shifts for colours with our observations.

The other members of this third group of Cp stars were also all discovered by Kurtz and are: HD 24712, HD 60435, HD 83368, HD 137949, HD 201601 and HD 217522. Kurtz proposed a simple model which looks very plausible, but unfortunately, is contradicted by theoreticians. His model is called the *oblique pulsator.*

For this model, the axis of pulsation is aligned with the magnetic field axis. Therefore a maximum amplitude should be observed when looking at the magnetic pole and no pulsation at all when looking at the magnetic equator. This picture corresponds exactly to what we observe. The pulsation amplitude is modulated by the stellar rotation. Secondary frequency peaks are observed in the power spectra relative to the main pulsation frequency and are separated by almost exactly the stellar rotation frequency. But here come the theoreticians. For an observer moving with the rotating star, Coriolis forces perturb the dynamics of the oscillations which lead to a precession of the pulsation axis. Consequently, the frequency splitting should not correspond exactly to the rotation frequency, but should be slightly larger. However, their very crude model calculations also predict to first order that the axis of pulsation should *not* be aligned with the magnetic field.

This time the observational evidence is very strong and different observers agree surprisingly well – at least in the eyes of somebody who has been working in this field already for some time. So we can relax and mumble, "Too bad for the theoreticians!" Can we really relax? Definitely not. More and better determined power spectra are necessary. Reliable abundance determinations and magnetic field measurements are lacking for most of the stars mentioned in this article and simultaneous light- and velocity measurements would considerably ease the difficult task of oscillation-mode determination.

And still more questions are in the air: Why do we observe such high overtones and only very few of them? Is the pulsation axis always aligned with the magnetic axis? Does the magnetic field, a density discontinuity or some other effect trap selected modes? How do rapid oscillations correlate with T_{eff}, log g, v·sin i, H_{eff}, i, β and Z?

There are lots of problems, but lots of exciting results can be expected. Why is not one of the telescopes on La Silla completely devoted to Ap star research?

Workshop on ESO's Very Large Telescope

A workshop on the subject of Very Large Telescopes (VLT) took place at the Institut d'Etudes Scientifiques de Cargèse (Corsica): it was attended by about forty invited participants. During three and a half days (May 16–19, 1983) the following topics were presented and discussed: scientific objectives for galactic and extragalactic research; instrumental requirements and possibilities (different wavelength regions, auxiliary instrumentation, detectors, interferometry, etc.); ESO's New Technology Telescope as a precursor to the VLT; projects existing outside ESO; ESO's VLT studies and options; site selection; general discussion. While it was undoubtedly too early to come to definite technical conclusions, a number of points were clarified and it was absolutely clear that there does exist a strong support on the part of the scientific community in Europe for the idea of a VLT. The workshop was followed in Cargèse by a meeting of ESO's Scientific and Technical Committee which strongly recommended the setting up of a group of persons whose activities will be entirely devoted to the VLT. Such a recommendation was endorsed by the Council on June 6: a VLT project group will thus be created so that technical studies, site surveys, etc. are to begin in the very near future.

The proceedings of the Cargèse VLT workshop are presently in press and their publication is scheduled for September 1983.

J.-P. Swings

Long-term Photometry of Variables at La Silla

C. Sterken, Astrophysical Institute, Vrije Universiteit Brussel

Many visiting astronomers at ESO are involved in the study of stellar variability on long time-scales (supergiants, Ap stars, pre-main-sequence stars . . .). Real "monitoring" of variables during a time-span of several years is almost impossible because allotted observing runs are too short and not continuous. The long gaps between the visits of an individual observer inevitably affect the homogeneity of the results (e.g. effects of changes in the instrumental system). A possible solution towards a more successful study of long-period variables is to select a restricted number of interesting objects of different type, and to observe them in an almost continuous way throughout succeeding observing seasons. Such an observing programme evidently calls for international collaboration in a well-organized team.

Early in 1982 such a programme was initiated by a dozen observers belonging to several European institutes. A number of individual observing programmes were merged and grouped into several separate research topics, and for each topic a principal investigator and a co-investigator were appointed. The following topics were selected:

	Main investigator	Co-investigator
1. Pre-main sequence stars	P. S. Thé	H. Tjin A Djie
2. Ap stars	H. Hensberge	J. Manfroid
3. Eclipsing binaries	H. Duerbeck	A. van Genderen
4. Be stars	D. Baade	A. Bruch
5. Supergiants	B. Wolf	M. de Groot
6. X-ray sources	M. Burger	M. Pakull
7. Events of opportunity	C. Sterken	

The last category consists of objects which need immediate monitoring due to the occurrence of an unexpected event (flares or bursts) or due to exceptional observational possibilities (e.g. simultaneous ground-based and space observations). Other topics may be added if necessary. The principal investigator selects objects which are suitable for observation, and the central coordinator (C. Sterken) finally submits the application to ESO.

The actual list of objects contains about 120 stars with right ascensions between 6 hours and 24 hours. About 50 % of them must be observed at a frequency of one measurement per night throughout the observing season. The frequency for observing the remaining stars ranges between one measurement every second day to one or two measurements per month.

It is obvious that only for the smaller telescopes one may hope to obtain sufficient observing time. The participants have expressed a strong interest in the use of the Strömgren uvby photometric system. This is the only photometric system which can be used at the Bochum 61 cm, the ESO 50 cm and the Danish 50 cm telescopes. The combination of an intermediate bandwidth filter system and a telescope of modest aperture obviously puts some constraints on the limiting magnitude of the selected objects, but the advantage of the Strömgren system in terms of physical interpretations is extremely important, and since the main emphasis of the programme is the long-term character, the uvby system was adopted.

Starting in October 1982, seven observing runs have already been granted. Each run has a typical length of about three to four weeks. The observers are participants who volunteer to carry out the measurements according to the adopted observing scheme.

All measurements are obtained in a differential way using two comparison stars for every programme star. Standard stars are observed each night, so that the measurements can be transformed to the standard uvby system.

All measurements are reduced by J. Manfroid (Institut d'Astrophysique, Université de Liège). Before leaving La Silla, the observer sends the magnetic tape with the measurements to Liège. Experience has shown that the reduction takes about two weeks, so that the principal investigator receives the results about one month after termination of the observing run.

This fast processing of the data has proven to be extremely useful, especially in those cases where unexpected changes in the light curves of one of the objects calls for immediate action (a flare-like event in the light curve of FU Ori was observed by D. Vander Linden in February 1983, and on request of H. Tjin A Djie the object was reobserved intensively during the next observing run). Another advantage is that instrumental deficiencies (e.g. deteriorated filters, wrong alignment . . .) are detected at once, and can be cured immediately.

The responsibility for the scientific value of the subprogramme rests entirely with the principal investigator; he also redistributes the final data belonging to his section. About once a year the available data will be published in *Astronomy and Astrophysics Supplement Series;* the author list of that paper will consist of the names of all observers who have contributed to these published measurements, and of the persons who carried out the reductions. The interpretation of the results and the scientific discussion are carried out by those persons who applied for the measurements.

Some interesting results are already available after this first full year of operation.

For several Ap stars, improved periods (in the range of 1 to 4 days) were obtained.

Nine pre-main-sequence stars have been monitored so far. The range of variation in y decreases for earlier spectral types, and significant night-to-night variations are found in some cases. The data for UX Ori and CD-4403318 were used together with IUE spectra for a discussion of their evolutionary status (H. Tjin A Djie, L. Remijn, P. S. Thé, 1983, in preparation).

About 200 uvby observations of a number of Be stars were obtained. HR 2142, a binary system with a period of 80.8 days, and seen at an inclination just small enough not to produce eclipses, is an outstanding object for a long-term programme. A cooler and less massive companion filling its Roche lobe loses matter which reveals itself through the shell lines when the gas stream is seen projected on the B-type star (Peters 1982, IAU Symp. 98, p. 311). According to this model, noticeable photometric variations should only occur during the shell phases. In

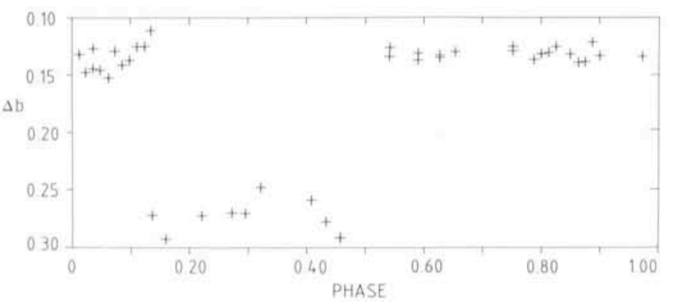

Fig. 1: *Differential b filter magnitudes HR 2142 – HR 2344 plotted versus phases of the 80.82-day period. Shell phases occur at phase 0.5.*

fig. 1, D. Baade has plotted our observations of HR 2142 (phase 0.5 corresponds to the primary shell phase) and shows that there is no modulation of the light curve with phase of the orbital period. Unfortunately the short shell phases (spanning less than 8 days) were missed twice as they fell outside the observing times. A more fortunate coincidence between shell phase and observing time will teach us more about the photometric activity during that phase. Fig. 1 also shows that the brightness of the star was essentially constant for most of the time, but on two different levels. Only from future long-term monitoring of this star can we learn if this $0\overset{m}{.}13$ decrease in all passbands is related to certain phases of the orbital period or if other periodicities are present.

Another highlight is undoubtedly the discovery of an S Dor-type outburst in the Of star R127 (See Wolf & Stahl's article in this issue of the *Messenger)*. A remarkable result is also the discovery of the binary nature of the luminous LMC supergiant R81. By combining older photometric data with data obtained by various observers in our project, F. Zickgraf (Landessternwarte Heidelberg) found a period of 29.18 days. Fig. 2 shows the average light curve. The residual scatter is larger than expected from the photometric accuracy, but this is due to intrinsic variability of the supergiant. The shape of the light curve indicates that R81 is probably an eclipsing contact binary. The star will be given highest priority during the September and December 1983 observing runs.

Besides the direct scientific results, the programme offers several attractive aspects. Young observers who have not established their own field of research may join one of the teams of our group, in that way they will acquire experience in different fields of variable star work. The project definitely stimulates international collaboration, especially for what concerns events of opportunity (e.g. simultaneous coverage with other ground-based or space observations).

There is also a close collaboration with Dr. J. Maza (Universidad de Chile) regarding information about events such as bright galactic novae.

The actual group consists of 22 participants. We do hope that more people from different countries will join the project.

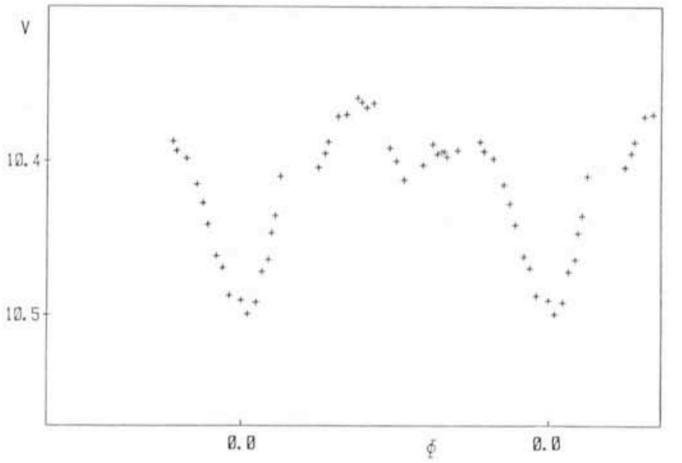

Fig. 2: *Average V-light curve of R81 constructed with a period of 29.18 days.*

Discovery of an S Dor Type Outburst of an Of Star at La Silla

B. Wolf and O. Stahl, Landessternwarte Heidelberg

What are S Dor Variables?

Back in 1897, E.C. Pickering reported on the variable star S Dor in the Large Magellanic Cloud (LMC). A quarter of a century later, J.C. Duncan (1922) and M. Wolf (1923) independently discovered a few variable stars in M 33. Since the extragalactic nature of these galaxies was not yet established in those days (i.e. their distances were not known) these authors could not realize that they had discovered some of the most luminous variables of the Universe with absolute visual

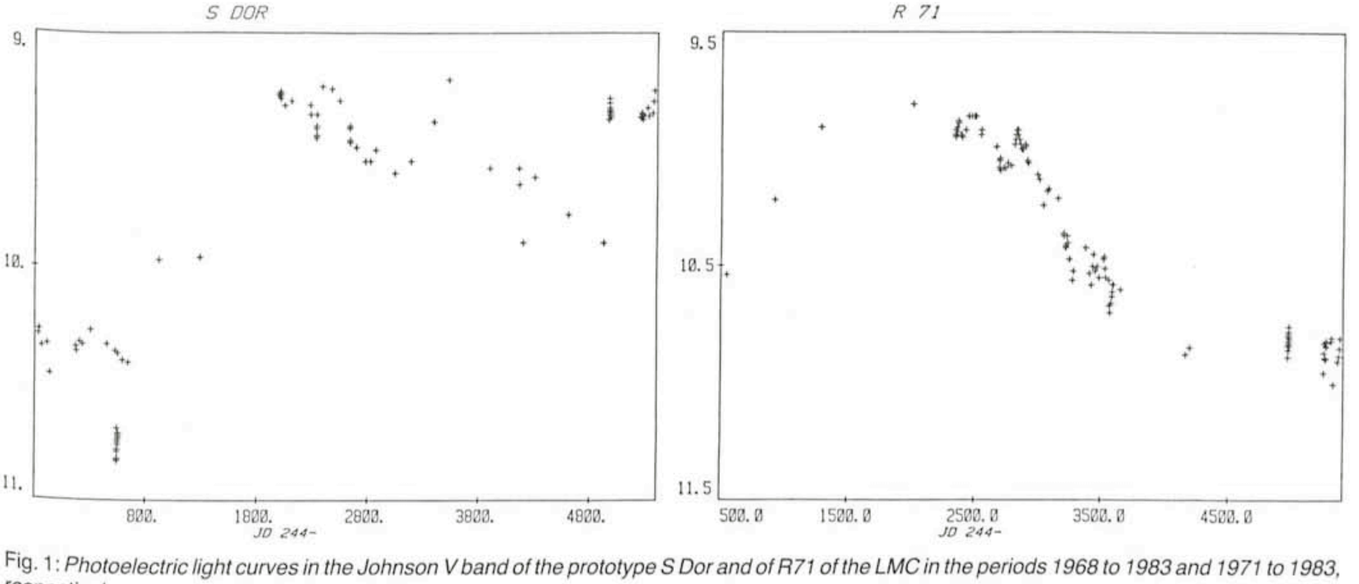

Fig. 1: *Photoelectric light curves in the Johnson V band of the prototype S Dor and of R71 of the LMC in the periods 1968 to 1983 and 1971 to 1983, respectively.*

magnitudes brighter than $M_v \approx -9$. Thirty years later, in 1953, Hubble and Sandage investigated these stars, nowadays called Hubble-Sandage variables or S Dor variables, in more detail. Their main characteristics are: (1) extremely high luminosity ($L \approx 10^6 L_\odot$), (2) spectral types: early B to F, (3) strong ultraviolet excess ($U-B \lesssim -0.8$) and infrared excess, and (4) variations of more than one magnitude in the visual spectral range on timescales of years to decades.

As will be shown below, the S Dor variables and related objects have recently gained considerable interest as a possible missing link in the evolution of very massive stars with stellar masses $M \gtrsim 50 M_\odot$. S Dor variables are also known to exist in the Galaxy. For instance, we have recently confirmed (Wolf and Stahl, 1982) that AG Car belongs to this class, and the enigmatic star ηCar has long been known to be at least related to this group.

Since the S Dor variables of the LMC are on the one hand comparatively bright ($V \approx 9$ to 11 mag) and their distances are on the other hand quite well known, our group has been particularly engaged in investigating these stars. It turned out that the combination of spectroscopy and photometry and the simultaneous observations in different wavelength regions (from UV to infrared) provide particularly interesting results.

Earlier Ground-based and IUE Observations of S Dor Variables in the LMC

One of the main characteristics of the S Dor variables is their light variability on timescales of years to decades. (Variations on shorter timescales [hours or days] are known, but these are of small amplitude.) In fig. 1 the light curves of the two

Fig. 2: *Section of coudé spectrograms (12 Å mm⁻¹) of S Dor during maximum taken with the 1.5 m spectroscopic ESO telescope. Note the pronounced P Cygni-type profiles of singly ionized metals and the considerable profile variations.*

established S Dor variables of the LMC (R71 = HDE 269006 and the prototype S Dor) are presented. The data were compiled from many sources in the literature and supplemented by our own measurements collected at La Silla.

It has long been known that S Dor variables are bluer during minimum by about 0.2 mag in B-V than during maximum. It was suggested earlier that the considerable brightness and colour variations are due to the ejection of massive envelopes during outburst. In fact the mass loss rates of S Dor variables during outburst are of the order of 5 to $10 \cdot 10^{-5}\ M_{\odot} yr^{-1}$, i.e. about a factor of ten higher than the rates found for "normal" hot stars. The strong mass loss is evidenced by the appearance of P Cygni-type profiles of singly ionized metals during maximum. Practically all lines are of P Cygni type indicating that the underlying photospheric spectrum is completely masked by the envelope. A sequence of spectra taken during a time interval of four years during the recent maximum of S Dor is shown in fig. 2. Considerable line profile variations are evident indicating that the mass loss mechanism differs from the one working in "normal" luminous stars. In addition, it is found from the spectra of S Dor variables that their winds are comparatively cool and that the mean expansion velocities are comparatively low (60–150 km s^{-1}). These low velocities are also shown by the recently obtained IUE high dispersion spectrum of S Dor. A section of this spectrogram is shown in fig. 3. In all cases where we investigated the spectra of S Dor variables in more detail, we found the wind to be decelerated outwards – also in contrast to the behaviour of normal hot stars. The strong UV- and IR excesses during outburst are a consequence of these wind characteristics. Fig. 4 shows that the mass loss of S Dor variables (and of related post-main-sequence envelope objects) is considerably higher than that of normal luminous stars.

We note that the spectra of S Dor variables during minimum show a rather normal early-type absorption spectrum often with superimposed forbidden Fe II lines or other forbidden lines, due to the diluted relics of the matter expelled during outburst. A good example showing the differences between the minimum and maximum spectrum was given by Appenzeller, Stahl and Wolf in the *Messenger* No. 25, Sept. 1981. We have concluded that S Dor variables are supergiants (hotter than previously thought) in a short-lived evolutionary phase characterized by considerably enhanced mass loss due to the occasional ejection of very dense envelopes.

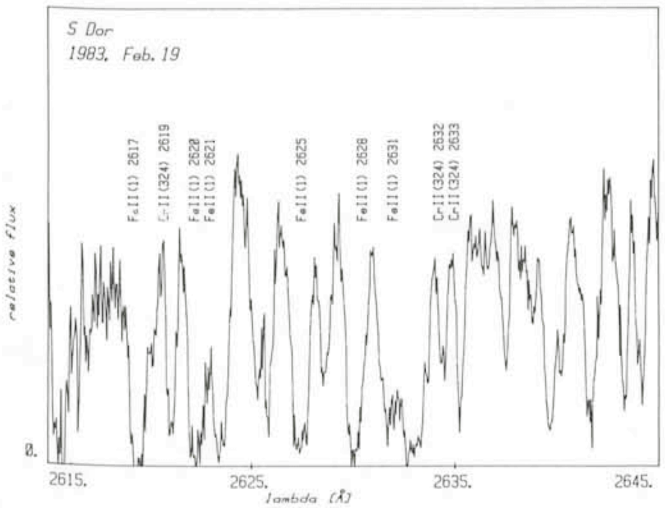

Fig. 3: *Section of a high-dispersion IUE spectrogram of S Dor taken on February 19, 1983.*

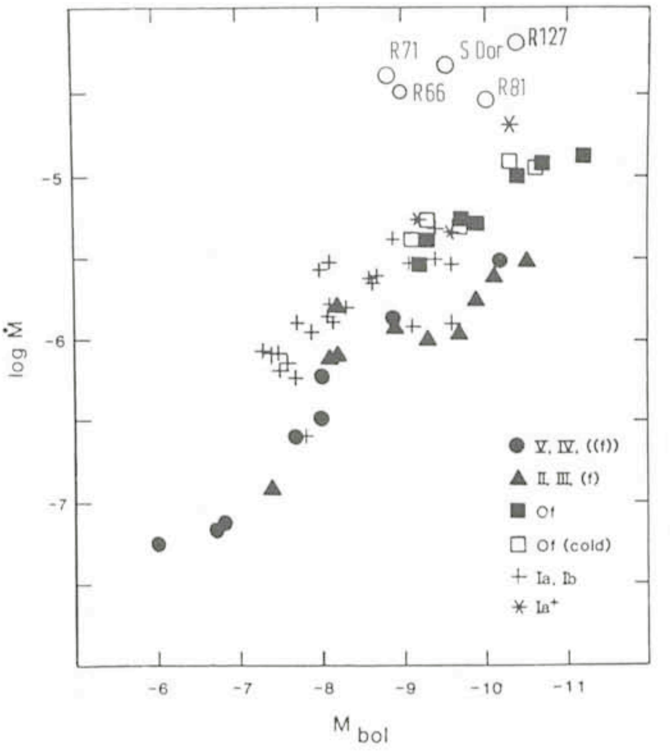

Fig. 4: *Location of the S Dor-type variables and related emission-line stars of the LMC in the diagram of Lamers (1981). Note the high mass loss rates of these objects compared with normal luminous supergiants.*

The New S Dor Variable R127 Intermediate Between Of and WN

It was conjectured earlier that the S Dor variables represent an important additional evolutionary phase in a scenario suggested first by P. Conti (1976). According to this scenario the very massive stars ($M > 50\ M_{\odot}$) evolve via Of to WN stars. A major difficulty of this scenario was that the observed mass-loss rates in the O- and Of phase appear to be not high enough to remove the hydrogen rich layers and expose the nuclear processed matter characterizing WN stars. Since the S Dor variables are losing much matter during their outbursts they may represent an important link between Of and WN stars. If this were true one would expect to find unstable Of stars with S Dor-type outbursts.

Therefore we included Of stars in a long-term monitoring programme searching for new S Dor variables in the LMC. Observing at La Silla on January 9, 1982, one of us (O.S.) found the extreme Of star R127 (= HDE 269858) 0.75 mag brighter in V than the value given by Mendoza in 1970. One week later the coudé spectrogram shown in fig. 5 was secured with the 1.5 m spectrographic telescope at La Silla. From these observations we suspected R127 to be a new S Dor-type variable. Therefore we decided to include R127 in the long-term photometric monitoring programme at La Silla, organized by Christiaan Sterken from Brussels (see his contribution in this issue of the *Messenger*). Within this programme we began to observe R127 on October 7, 1982 and found it to be as much as 1.3 mag brighter than Mendoza's V value. The observations obtained within this programme are shown in fig. 6. No doubt R127 has undergone an outburst. Both the light curve and the spectral appearance prove that a new S Dor variable has been discovered at La Silla. Needless to say that we now became eager to have this star observed with various kinds of instruments. R127 was subsequently observed by Italian colleagues

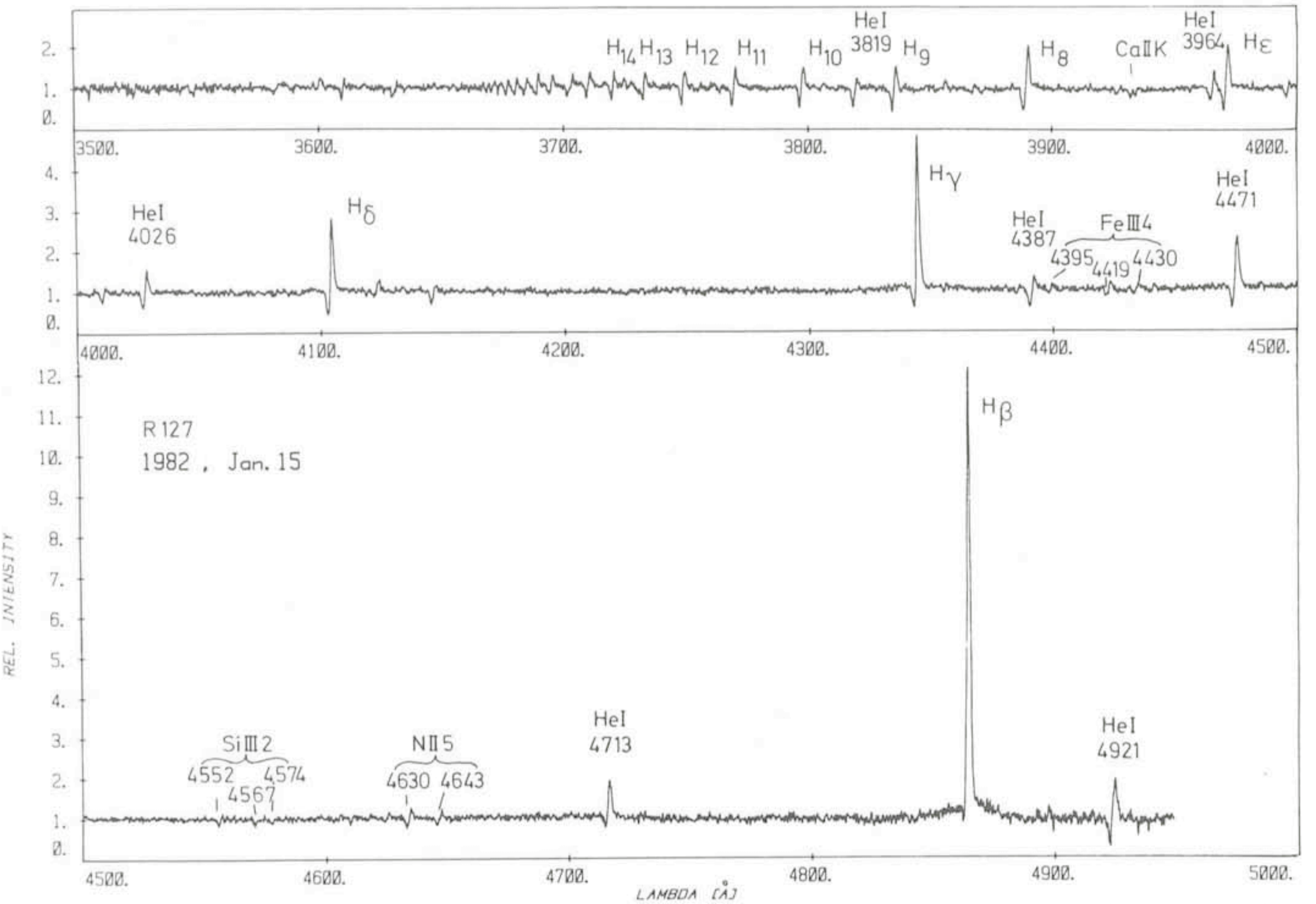

Fig. 5: *High-dispersion (20 Å mm^{-1}) spectrum of the newly discovered S Dor variable R 127 in the LMC (taken with the coudé spectrograph of the ESO 1.5 m telescope). Nearly all lines identified in the figure show pronounced P Cygni-type profiles.*

with the IDS attached to the 1.5 m telescope and with the infrared photometer (JHKLM) at the 1 m telescope. Further we spent 3 complete shifts with the IUE to observe R127 several times in the high and low resolution mode of both wavelength ranges 1200–1900 and 2000–3000 Å).

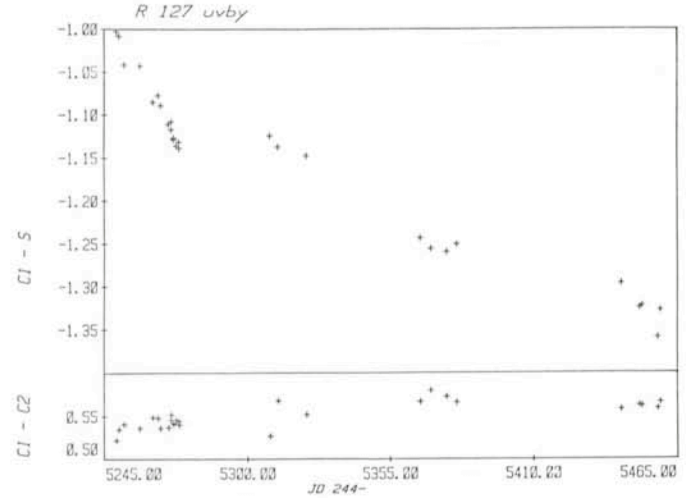

Fig. 6: *Strömgren y-magnitudes of R127 obtained within the photometric long-term monitoring programme, organized by C. Sterken, Brussels. The Bochum 60 cm telescope at La Silla has been used by various observers during this campaign from October 1982 to May 1983. A completely differential method is applied. Two nearby comparison stars (HD 37722, V = 8.84 and HD 37584, V = 8.30) were used. C_1-C_2 below the light curve indicates the photometric accuracy.*

Particularly interesting results were obtained with the IUE in the long wavelength range. Crowded lines of singly ionized metals were conspicuous in the spectrum of this Of star (!). The lines were split into three subcomponents as shown in fig. 7, indicating a very complex shell phenomenon.

We note that R127 is a particularly interesting member of the menagerie of S Dor variables. Its pre-outburst spectrum was classified by Walborn (1977) as Olafpe extr. It is the hottest S

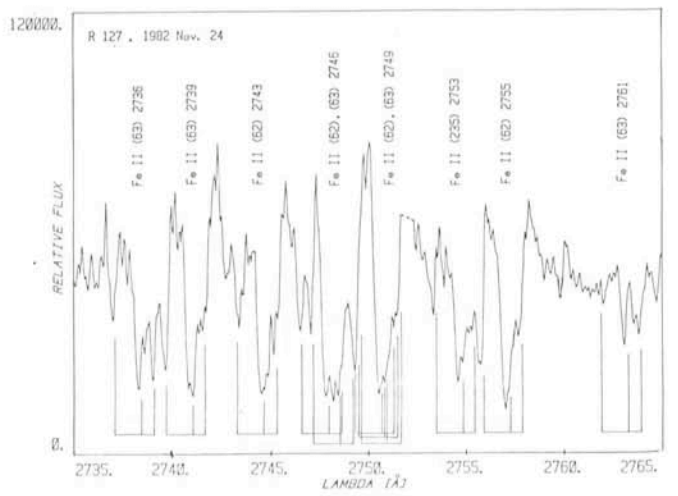

Fig. 7: *Section of high dispersion IUE spectrogram of R127. Note the triple substructure of the strong Fe II absorption lines. A very complicated shell structure is indicated by this.*

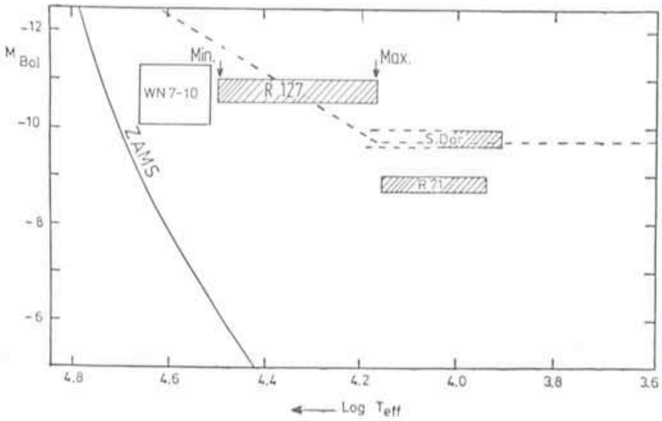

Fig. 8: *Location of the newly discovered S Dor variable R 127 in the Hertzsprung-Russell diagram in comparison with the other two established S Dor variables of the LMC. Also included in the figure is the upper envelope of known stellar absolute bolometric magnitudes as derived by Humphreys and Davidson (1979). The approximate position of the late WN-type stars is also given.*

Dor variable detected and intensively studied so far. It is also one of the most luminous stars of its class with $M_{bol} \approx -11$ both during minimum and maximum (in contrast to the variations in the visual by 1.3 mag). Like for the other S Dor variables we explain this particular finding by the very high mass loss ($\dot{M} = 6 \cdot 10^{-5} M_\odot yr^{-1}$) during outburst. The variations in the visual are caused by bolometric flux redistribution in the envelope whilst the bolometric luminosity remains practically constant.

The location of R127 in the Hertzsprung-Russell diagram together with the other two known S Dor variables of the LMC are shown in fig. 8.

We note that Walborn classified R127 as an Of or alternatively as a late WN-type star. This indicates that the star is a late Of star evolving right now towards a WN star. Since we have detected an S Dor-type outburst of this star we conclude that this transition is not a smooth one but is instead accompanied by the occasional ejection of dense envelopes.

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Observations of Comet IRAS-Araki-Alcock (1983d) at La Silla

T. Encrenaz, Observatoire de Paris, and H. Pedersen and M. Tarenghi, ESO

As mentioned already in the last issue of the *Messenger*, a very exciting comet crossed the Earth's neighbourhood a few months ago. First discovered by the infrared satellite IRAS, then by two amateurs, Araki (Japan) and Alcock (UK), this comet approached the Earth with a minimum distance of 0.03 AU on May 12, 1983. The previous record of such a minimum distance was in 1770 with Comet Lexell.

This event provided a unique opportunity for studying a comet at very high spatial resolution. This is of major interest

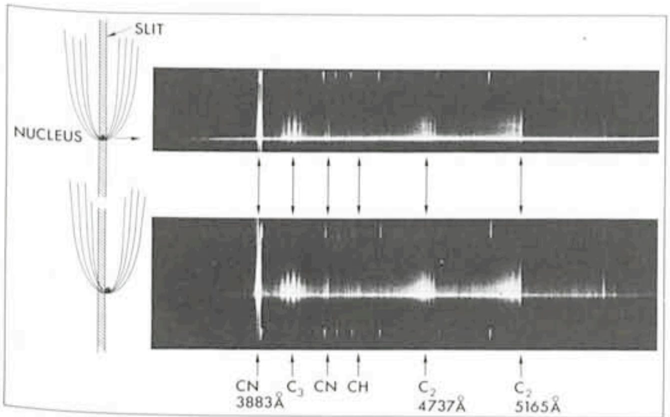


Fig. 1: *Image-tube spectra of Comet IRAS-Araki-Alcock obtained with the 1.5 m ESO telescope on May 13, 1983 at UT 00:20. The upper spectrum includes the nucleus (exposure time 2 minutes), while the lower spectrum has been obtained with the slit of the spectrograph out of the nucleus.*

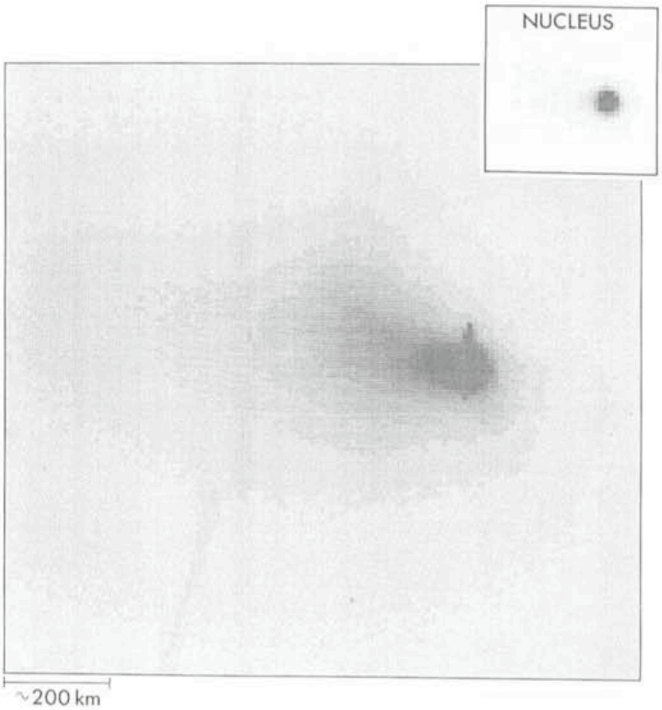


Fig. 2: *CCD images of the comet obtained in the Z filter (10000 Å) at the 1.5 m Danish telescope. In the 5 min. exposure image the nucleus is saturated. The insert image of the nucleus has been obtained with an exposure time of 1 min.*

since most of the information about the nature and the origin of comets lies in the central region – the nucleus and its immediate environment – which are usually too small to be observed from the ground. In the case of Comet IRAS, a spatial resolution of about 10–20 km could be reached at the time of closest approach.

Comet IRAS was observed with three instruments at La Silla: IDS spectra were obtained at the 3.6 m telescope, and image-tube spectra (fig. 1) with the 1.52 m telescope; CCD pictures were recorded at the 1.54 m Danish telescope. These data are now under reduction.

Since the spectra were recorded at several points of the comet, in the inner coma and outside, we hope to derive information upon the abundances of radicals as a function of their distance to the nucleus, which is important for the understanding of the dissociation processes which lead from the parent molecules (ejected from the nucleus) to the daughter molecules and the radicals observed in a larger scale. This would be especially interesting for Comet IRAS where the parent molecules H_2O and NH_3 have been detected at radio wavelengths. The CCD pictures (fig. 2), with a scale of about 0.5 arcsec per pixel, might be able to confirm the visual observations reported by S. Larson (IAU Circular No. 3811) which suggest the existence of a 12 km cocoon surrounding the nucleus, and the radar observations of Campbell et al. (IAU Circular No. 3811) also suggesting the presence of a "skirt" around the nucleus.

Recent Results of IR Speckle Interferometry at ESO

C. Perrier, ESO

Our speckle system was implemented in late 1979 on the 3.6 m telescope. Although at that time every component was in a preliminary state, we could record results useful enough to prove the feasibility of such a high spatial resolution instrument. The astrophysically usable results came later in 1981 together with sensitivity gain of the IR photometer (Perrier, 1981, *The Messenger* No. 25, p. 26). Since then we have entered a period of studies of specific astrophysical targets, some of which will be reported in this article.

In the meantime, the pioneering work done by Sibille, Chelli and Léna (1979, *Astronomy and Astrophysics* **79,** 315) triggered the development of similar instruments at the Anglo-Australian, K.P.N.O., IR Facility and Canada-France-Hawaii telescopes. This recent interest in IR speckle instruments is related to the lack of high angular resolution of objects suffering a high extinction. Especially concerned are those discovered in the systematic search for compact IR objects which is currently being carried out in molecular clouds (like the Orion complex), but also some exotic objects whose mass loss (e.g. η Car, IRC+10216) or activity (NGC 1068) is better studied in the near infrared where the inner regions become visible. These instruments are also well suited for the search of IR companions as shown by the spectacular discovery of the one of T Tau (Dyck et al., 1982, *Astrophysical Journal* **255,** L103).

The trend to expand the access to such facilities cannot go without developing more reliable observational procedures and more powerful reduction techniques. Part of them have already been exposed by Mariotti et al. (1983, *Astronomy and Astrophysics* **120,** 237) and a thorough review has been done by Bates (1982, *Physics Reports,* **90,** 203). We shall give here some indications of these advances besides the presentation of the results.

Some Instrument Related Remarks

Let us in short see what the speckle observing procedure looks like. A description of the system was published in the *Messenger* No. 25 but it has evolved now to a more sophisticated one and will do so until an optimized version, physically separated from the photometric facilities, comes into use one year from now. Thus no updated documentation exists.

The standard speckle procedure gives on-line access to the visibility or 1-D Fourier Transform (FT) modulus of the intensity distribution (see e.g. Léna, 1981 in "ESO Conference on Scientific Importance of High Angular Resolution"). The observation must be repeated several times to ascertain sufficiently low statistical errors. When the reference source is only a few degrees away from the object it is now possible to alternate very frequently allowing a sequence "Ref.-Source" to last less than 5 minutes. A series of sequences is computer-controlled, so no time is lost by manual pointing. In this way the seeing variations are minimized.

Some objects allow a non-standard procedure: if they are close enough (a few arcsec) they permit a "source switching" very similar to the photometric beam switching. The 3.6 m telescope can perform this accurately enough every 10 seconds for any scanning direction and offset vector. This procedure is most useful for objects otherwise too faint for an accurate guiding. The reference star serves for this and of course for the mean transfer function measurement. This fast switching mode also provides adequate conditions for the image reconstruction of extended sources.

As stated before, our technique is well suited for the study of a wealth of objects, even with its present limiting magnitudes – e.g. L≃5 at 3σ with a one-hour sequence and a 2-arcsec seeing – still 2 to 2.5 magnitudes below their optimum values. We have focused our work on objects showing an intense IR excess and the 10 μm silicate feature, indicator of circumstellar dust grains. They have large dust envelopes usually due to high mass loss rates. Often these are so large that the shell

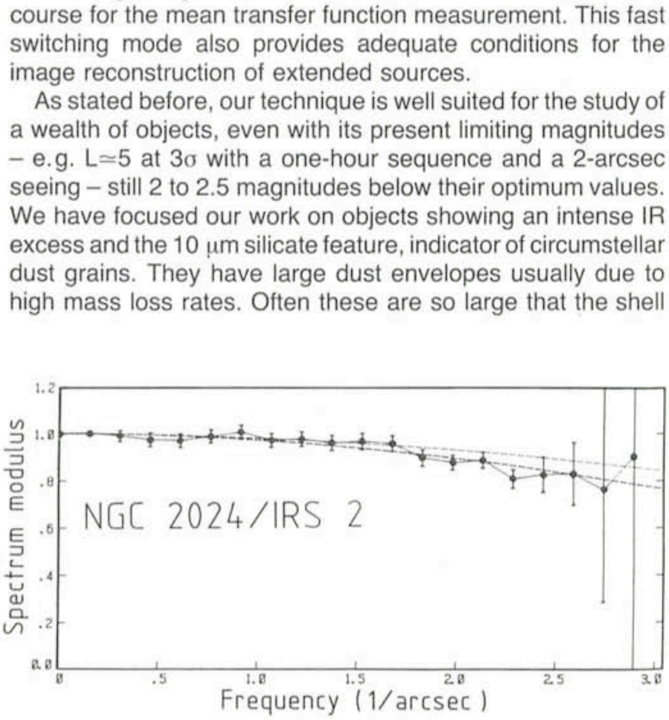


Fig. 1: *Visibility of NGC 2024 #2 fitted with theoretical filled-disk spectra of diameters 0.12 and 0.15 arcsecond λ = 4.64 μm. Position angle = 90°. The error bar is the standard deviation from the mean for several independent observations.*

gets thick enough to almost completely absorb the visual light from the star and re-emit this energy at the temperature of the shells.

We first consider two pre-main-sequence or early-type objects which fall into this class of IR emitters.

Young Objects in the Orion Molecular Cloud

(a) The Source NGC 2024 # 2

The role of this embedded object in the second complex source of the region is still not clear. In particular it could be a highly reddened star exciting the nearby bright H II region, or a star with an envelope in a compact H II region. Near infrared spectra by Thompson et al. (1981, *Astrophysical Journal* **249,** 622) give a B_γ line flux consistent with an underlying B 0.5 ZAMS star. Speckle observations of this object were made at 4.6 μm in April 1982 and give direct support to Thompson's view by substantiating a complete model of #2 (Jiang, Perrier and Léna, submitted to *Astronomy and Astrophysics).*

In this case the usual Labeyrie method is used where the observed power spectra are co-added and corrected from the mean atmospheric + telescope transfer function. For a size close to or below the diffraction limit of the telescope, there is not much to learn from a true image and thus we do not need the phase information (of the complex FT). It is sufficient to check for a possible object asymmetry by scanning at perpendicular directions as we did: we obtain an equivalent filled disk diameter d_{fd} = 0.12 arcsec (fig. 1).

The filled disk assumption is not compatible with the photometric data whatever the extinction is, except for abnormally high values. But using a model of an optically thin dust envelope (Allen et al., 1981, *Monthly Notices of the Royal Astronomical Society* **196,** 797) defined by an inner boundary r_{in}, a density law αr^{-2} and a temperature law $\propto r^{-2/5.5}$ one finds an inner radius of 0.03 arcsec and can account well for the observed spectrum and derive other parameters: an interstellar extinction of 21.5 m, a shell inner temperature of 1,160 K. With the B_γ line flux, one finds a B 0.5–0.2 type for the central ZAMS star. The properties of the shell can then be defined: it is formed by the stellar wind which drives a mass loss of 1.5 10^{-6} $M_\odot$.yr^{-1}, responsible in turn for the compactness of the H II region; most of the condensed phase is made of graphite grains. From the comparison of luminosities involved one deduces that the cloud causing the extinction must be well detached from the object and is mainly heated by some other sources.

(b) IRc2 in the KL Nebula

In the core of the Orion nebula, the infrared sources clustered in the Kleinmann-Low (KL) nebula have very large extinction. The energetic balance, polarimetric and radio observations have made it clear, although recently (Downes et al., 1981, *Astrophysical Journal* **244,** 869), that one of them, IRc2, a secondary source close to the more prominent well known Becklin-Neugebauer (BN) object, was the very reddened energy source powering the whole cloud. In order to observe this relatively faint source one can take advantage of the proximity of BN (at 9 arcsec), known to be quasi point-like at 5 μm, not only for guiding but as a deconvolution key. This means that a scan gives the point spread function of the telescope and the seeing degraded image of the object simultaneously. Thus a deconvolution may be performed leading to the true 1-D image which would otherwise be inaccessible at M for the 3-magnitude object IRc2.

We recorded some 8,000 scans in November 1982 at a position angle (PA) of 142°, the exact direction of the BN-IRc2

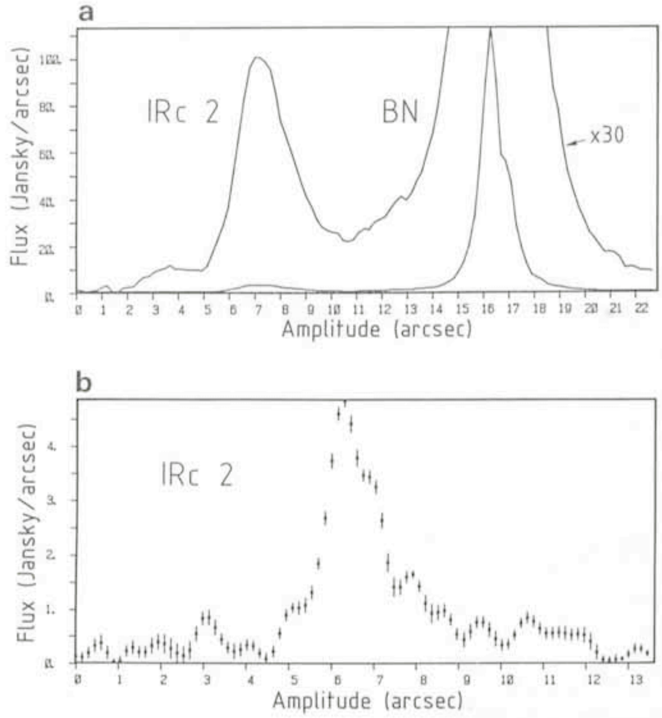


Fig. 2a: *Average of scans obtained at 4.64 μm on IRc2 at different scales. IRc2 is on the left, BN on the right. The bridge linking the sources is due to instrumental diffusion and cancels out with a proper calibration.*

b: *Final 1-D image after deconvolution. The resolution is 0.5 arcsecond. The error bars represent the standard deviation from the mean for 20 independent results. The calibration refers to the integrated flux along the slit and relies on the measured magnitude of BN. Note the feature at 3 arcsec whose width (0.5 arcsec) equals the resolution: it remains unresolved and could have something to do with the activity of the central source.*

line. IRc2 shows up in the left half of the average given in fig. 2a. The signal to noise has been greatly improved since it was 0.5 for individual scans. In the reduction, we selected the best images, recentred them with respect to the maximum of BN and built 20 independent blocks by averaging 400 scans. A simple deconvolution by the BN profile produced the image of fig. 2b giving the calibrated object profile. All the interpretation relies on this high resolution photometry and is exposed in Chelli, Perrier, Léna (1983, submitted to *Astrophysical Journal* lett.).

First, the source is well resolved with a size of 1.4 arcseconds. A dereddened temperature of 360°K and a 3.6–12.5 μm (excluding the silicate absorption) optical depth of 5.2 lead to A_v = 170 mag. Thus the luminosity derived from the size is 8.10^4 $L_\odot$, a large fraction of the cloud luminosity (Genzel and Downes, 1982, *Regions of recent star formation,* Reidel ed.). This directly confirms IRc2 in its role of primary source of the cloud. Second, the profile exhibits some features like a shoulder in the central core. We can interpret this central component as a double source with an intensity ratio of 2. This figure agrees very well with the radio observation consequences. They show evidence of a gas velocity structure consistent with a "doughnut"-like source and a high velocity outflow along its axis (Wright and Plambeck, 1982, preprint). Moreover, the positions of the SiO masers, well structured in a double lobe emission, coincide with IRc2 (Wright and Plambeck, 1983, preprint). We can derive the inclination of the axis with respect to the sky plane and explain the difference in IR intensities with the local extinction given by the model. The radio and IR observations converge now toward a scheme where IRc2 is a highly active component of the complex. To improve further the knowledge of its structure, new observations in other directions and wavelengths are planned.

Visibilities of other interesting young objects have been measured and deserve some more insight, for instance RCW 57/IRS 1 which shows a faint core in a very extended structure.

Evolved Objects

(a) The Active Object η Car

η Car is quite exceptional in many aspects like its brightness (M (4.6 μm) ≃ −3.4, this makes it one of the strongest near IR sources; its distance is 2.8 kpc), or the clumpy aspect of the fast outward-moving cloud of surrounding material. Some violent event is known to have occurred in the mid-nineteenth century. We probably see now the result of it through the long-term decrease in brightness due to dust formation. The nature of the central object is still a disputed question. Yet its very high luminosity (~ $10^7\ L_{\odot}$) suggests that it is in a rapid evolutionary stage, an idea consistent with the behaviour of high mass post-main-sequence objects (Davidson et al., 1982, *Astrophysical Journal* **254,** L47). In any case a multi-component system, preferably with ejected condensations, is not excluded. Therefore the spatial information may bring decisive clues to these problems. In the infrared the best spatial resolution was attained by Hyland et al. (1979, *Astrophysical Journal* **233,** 145) who discovered a secondary inner component at 1.1″ from the centre at 3.6 μm. We therefore had good reasons to observe this source, lowering the resolution to 0.1 arcsec or so.

It turned out that η Car was a complex source at K (2.2 μm) and M at the sub-arcsec scale. In order to extract the available astrophysical information from our data, we had to go further than simple visibility computation. With this aim, we used a technique of image reconstruction relying on algorithms not yet applied to real IR data (Chelli, Perrier, Biraud, 1983, *Astronomy and Astrophysics* **117,** 199). Its main features in addition to normal speckle processing are:

(i) to select the diffraction-limited images (in the 1-D sense) which happen to be frequent at 4.6 μm under very good seeing conditions as shown by Fried (1978, *J.O.S.A.* **68,** 1551).

(ii) to compute the FT phase of the image, usually not recorded because of noise, by means of the so-called Knox and Thompson algorithm (1974, *Astrophysical Journal* **193,** L45).

(iii) to restore the image by inversion of the FT in the "maximum entropy" sense (well known in radio applications); this provides the smoothest image compatible with the data and their noise. The solution is an image where no a priori information has been arbitrarily added.

Two examples are given in fig. 3. The scanning direction is 150° with respect to north for both wavelengths. The central peak is resolved in both cases according to the spatial frequency-limited resolution. The secondary component, well defined at K, is merged into the central peak foot by the degraded resolution but could also have a higher colour temperature than the central core envelope. The bump in the M image corresponds to low temperature material which produces the envelope seen in all directions at 4.6 μm.

The 1-D images cannot provide a clear idea of the overall structure. The next step consists in restoring the 2-D image by using simultaneously the information obtained for all directions which covers conveniently enough the spatial frequency plane. Preliminary results do confirm the very clumpy structure inferred from the past activity of η Car. We intend to analyse the

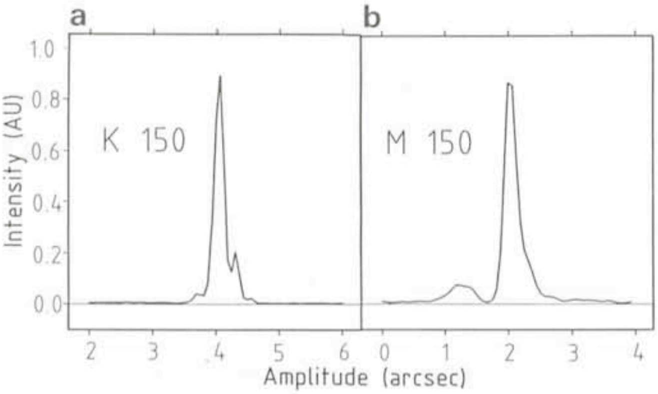


Fig. 3: *1-D images of η Car at PA = 150° represented with arbitrary intensity units. a − λ = 2.2 μm. Resolution is 0.15 arcsecond (see text). b − λ = 4.64 μm. Resolution is 0.20 arcsecond.*

recent models hypothesis in the light of the final map. But it is already obvious that the present models rely on photometric data which are too biased by the significant departure from the simple-minded geometry assumed. Moreover the complex structure probably contains two or three secondary components with various colour temperatures.

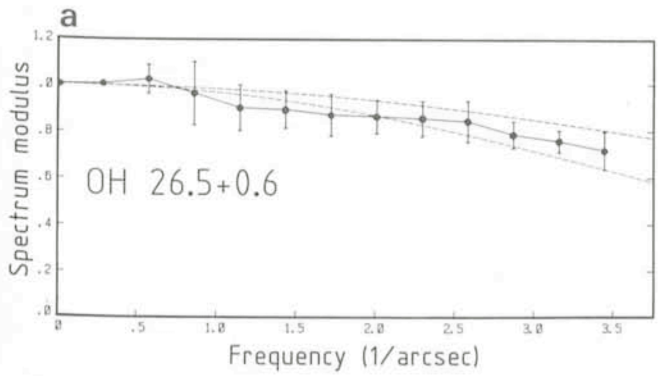
(b) Very Long Period Variable Stars

We now consider some late-type objects surrounded by very thick circumstellar shells and completely obscured in the visible, with a variability with a period of years. These intense IR emitters were detected by sky surveys or IR counterpart searches of OH masers with which they are associated (Engels 1981, *The Messenger* **24,** 24). The double-peaked radio spectrum shows that the shell is expanding radially.

A prototype of these objects is OH/IR 26.5+0.6, a Mira variable with a 1,630-day period and mean magnitudes K=8.9, L=1.9 and M=0.0. Its amplitude at L is 2.4 mag, the mean K-L colour temperature of the shell is 380 K with an amplitude of 80 K. The bolometric luminosity of this star varies over 2 mag about a mean of −7.0 mag (adopting a distance of 2.2 kpc). An equivalent black body, of temperature 380 K, would have linear diameters of $9.2\ 10^{15}$ and $5.6\ 10^{15}$ cm respectively at maximum and minimum light. These values correspond to angular diameters of 0.28 and 0.16 arcsec very well suited to IR speckle interferometry. Yet, as the temperature is decreasing radially outwards, one expects that the angular diameters increase with wavelengths. So the above diameters are only mean values. As most of the energy is emitted beyond 5 μm, angular diameters measured at shorter wavelengths should be smaller than those computed for a black-body.

Visibilities of this object have been obtained at several epochs covering a period of two years. Fig. 4 shows two results at M obtained about one year apart in the east-west direction. In fig. 4a, a diameter d_{fd} = 0.14±0.02 arcsec was computed at phase 0.67 (June 1981); in fig. 4b, d_{fd} = 0.17±0.02 arcsec at a phase close to maximum. Actually we started to monitor this source regularly to get the size as a function of magnitude directly. These sizes and their variation with the energy input from the star are crucial parameters of the model calculations applied to the shell which require the knowledge of the inner and outer radii to start any spectrum synthesis (Butchart and Whittet, 1983, *Monthly Notices of the Royal Astronomical Society* **202,** 971).

Another characteristic of these objects relates to the possibility of probing the shell geometry with radio interferometry. OH



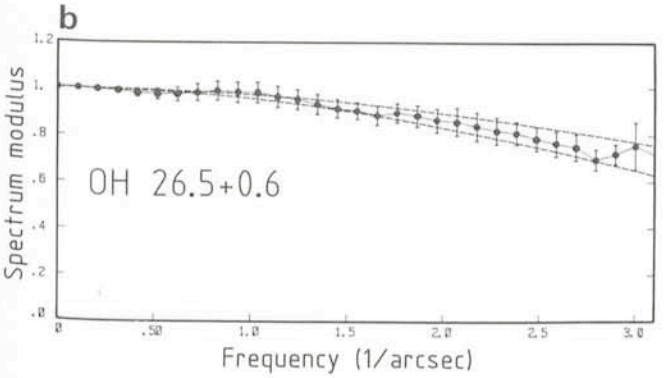


Fig. 4: *Visibilities of OH/IR 26.5+0.6 at 4.64 μm. The scanning direction is east-west.*
a – *June 1981, the large errors at ~ 0.8 arcsec^{-1} come from seeing effects.*
b – *April 1982 (near maximum light). The improved step in frequency comes from a wider scan amplitude. Note also the smaller range of errors due to improved performance.*

26.5+0.6 appears to have a fairly complex gas shell structure at the arcsecond scale with an internal component elongated east-west like a disk seen edge-on as proposed by Baud (1981, *Astrophysical Journal* **250,** L79). Thus it is of prime importance to confirm the expected asymmetry of the emitting dust structure whose kinematics can no longer be interpreted as a simple spherical expansion. Our study aims now to obtain the size in at least two scanning directions.

In our programme, some other OH masers are included, but they belong to both types, depending on which – the main (Type I) or the satellite (Type II; like OH 26.5 + 0.6) – emission line is actually dominant. OH 308.9+0.1, observed in June 1981, is very small at H (d_{fd} < 0.1 arcsec) and has IR characteristics which, in addition to its type I OH maser spectrum, relate it to protostellar objects (Epchtein et al., 1981, *Astronomy and Astrophysics* **97,** 1). Thus the classification "OH/IR" covers very dissimilar mechanisms.

Conclusion

Other types of source were present in our programme. Much is still to be reduced or interpreted but worth mentioning are the observations of the Seyfert galaxy NGC 1068 in four directions in filter L. The visibility at a PA of 45° gives the highest size with an equivalent d_{fd} of 0.40 arcsec whereas other PA yield 0.20–0.25 arcsec. This actually corresponds to the direction of the radio-jet (Pedlar et al., 1983 *Monthly Notices of the Royal Astronomical Society* **202,** 647). This result clearly illustrates the widely spread application field of IR speckle interferometry.

We anticipate to use soon a more efficient instrument which should make it possible to extend the list of accessible objects as well as to provide visibilities of bright objects with smaller statistical errors. This progress comes at a time when released IRAS data may offer new interesting sources and the CERGA long base line two-telescope interferometer may complement speckle results with a higher resolution.

The work presented here was done in collaboration with A. Chelli and P. Léna who promoted it and are largely involved in all the aspects. D. Engels and R. Foy are participating in the evolved object programme. Most of the computer work was supported by ESO La Silla and Munich. I wish to thank M. Maugis and J. Roucher (La Silla) for their permanent and essential support.

A Bright and Extreme W UMa-type Binary: ε Cr A

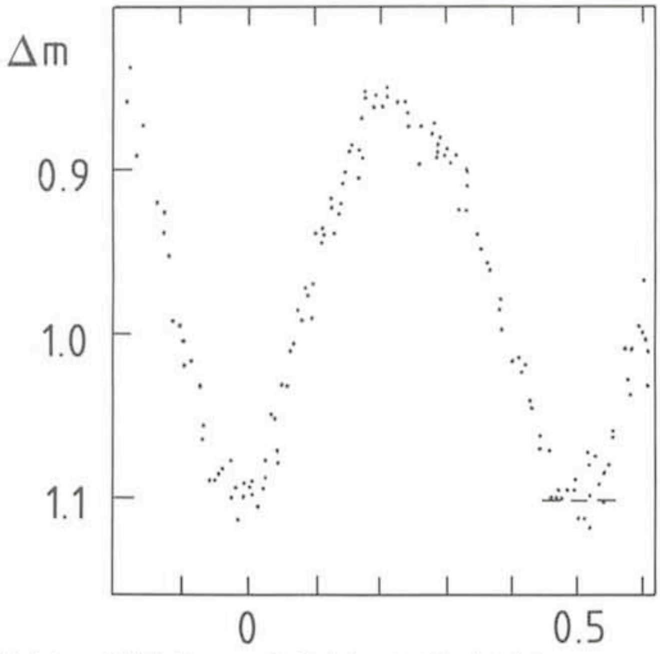
M. Lunel and J. Bergeat, Observatoire de Lyon

The W UMa Systems, a Mystery of Stellar Evolution

The light curves of close (eclipsing) binaries are not flat between eclipse intervals, due to proximity effects (tidal distortion, light reflection on facing hemispheres). The separation of the two components is so small in W UMa systems that continuous variations are observed in the light curves. Minima are nearly equal (see fig. 1) which means similar colours and effective temperatures for both components (spectral types A to K). They are also spectroscopic binaries. Individual masses and radii of the components can be derived in the most favourable cases. Apparently, they prove to be dwarf stars not too far from the main sequence.

Further advances in the analysis reveal astonishing features. The luminosity ratio between components is roughly proportional to the mass ratio, instead of the fourth power of the mass ratio as usual for dwarfs (for instance, the luminosity ratio is nearly 2 : 1 for a 2 : 1 mass ratio instead of 16 : 1). As a consequence, the spectra of secondaries (less massive stars) can be observed and the amplitudes of light curves do not exceed one magnitude. Recent modeling of light curves on computers shows that the surfaces of the elongated components are actually in contact. As a basic feature, recent theories include the transfer of energy from the primary to the secondary, through a common envelope which could explain the anomalous luminosity ratio. We would be observing rotating "dumb-bell configurations". This interpretation is however confronted with considerable difficulties when the internal structure of the components is investigated and no satisfactory model is yet available.

The contact systems of periods less than one day outnumber other binaries by a factor of (at least) ten. This is an additional difficulty since computations suggest that such configurations should represent a short-lived phase of stellar evolution. Fast evolution is also indicated by period variations (see section 4) but the subject is a matter of controversy. Finally, we have to



An infrared (K) light curve of ε CrA (see text for details).

explain why candidates for progenitors or descendants are so rare.

The Light Curves

Before the 1950s, most light curves were obtained from photographic observations. They always showed curved minima which were interpreted in terms of partial eclipses. Since then, however, intervals of constant light have been observed in the minima of more than 15 out of about 60 systems which have accurate light curves secured through photoelectric photometry. Those systems exhibit total eclipses.

The primary (more massive star) is easily identified with the larger, more luminous component since temperatures (and spectral types) are similar for both components. Binnendijk (1970) classified W UMa systems according to A-type (the primary star is eclipsed at the primary – deeper – minimum) and W-type (the primary star is eclipsed at the secondary – shallower – minimum). Total eclipses (occultation) are eventually observed at the secondary minimum of A-type systems and primary minimum of W-type systems, respectively. Complicated by the limb-darkening and gravity-darkening effects, the interpretation of minima depths in terms of temperature differences between components is a tricky job. According to the present state of the art, it seems that most A-type systems do have thick common envelopes. The A-type systems could be, in some sense, more extreme or more evolved, as suggested by other pieces of evidence.

The choice of ε Cr A

Strong perturbations (> 0.03 mag) have been ascertained in the light curves of various systems, which are tentatively interpreted as stellar spots or currents of ejected matter. In the northern hemisphere, we have frequently observed 44 i Bootis in various colours from the ultraviolet to the infrared. Infrared light curves proved valuable due to a low coefficient of (terrestrial) atmospheric extinction: typically 0.1 mag per unit air mass. A high accuracy being needed, ε Cr A is a good candidate since it is the brightest system, at least in the southern hemisphere. 44 i Bootis is a triple system and the light of a third, non eclipsing component is added. Moreover, 44 i Bootis is a typical late W-type system with its 2 : 1 mass ratio, while ε Cr A is an early A-type system with an extreme mass ratio of nearly 10 : 1 between components. It is quite interesting to compare their stability and light curve perturbations.

Period Variations

Observed periods range from one quarter of a day to one day. As a general trend, systems with shorter periods have later spectral types. Any observed change in the period of those variables is quite interesting. The observers plot a value which represents the difference between the epoch of observed minimum and the epoch of computed minimum, that is (O–C), against time in either Julian days, years, or number of cycles. The computed epoch is a value predicted from the previously determined period. Several possibilities appear. If the points are distributed on a horizontal line, it means that the period of the system is constant. If they define two straight lines of different slope, a sudden change of period is indicated. Sometimes, there are erratic variations. A smooth curve means that the period has changed continuously: this is the case for the system VW Cep whose (O–C) and period are slowly decreasing. Period changes can be attributed to different causes. Among them, mass loss or mass exchange are most plausible. According to Huang (1956), the period decreases when a component loses mass to its companion. The period increases when mass is lost to the system.

Different types of period variations are observed and it is interesting to monitor times of minimum light. The systems which undergo total eclipses lead to more accurate determinations of orbital elements than systems with partial eclipses. If a light curve is not well-defined, it is difficult to distinguish which minimum is the primary.

By definition, a typical light curve of a W UMa system has very curved maxima and minima nearly equal in depth. The light varies continuously and complete observations are interesting. Light curves do not repeat faithfully from cycle to cycle and it is valuable to observe the complete period during the same night whenever possible.

The Observations of ε Cr A

ε Cr A was discovered as an eclipsing binary in 1950 by Cousins and Cox who gave a period near $0^{d}\!.8406$ and a range of magnitude variation of 0.26. Cousins (1964) published a photographic light curve of ε Cr A and reported a small variation of period; blue and yellow filter observations were made by Knipe (1963–64) who used a 9 inch refractor and a photoelectric photometer. Other observations were reported in 1965 by Binnendijk.

Since that time, Tapia (1969) and Hernandez (1972) have published photoelectric U B V R and I observations obtained in 1967 at the Cerro Tololo Inter-American Observatory. Their observations are well represented by the following equation:

$$\text{HJD mini} = 2439707^{d}\!.6619 + 0^{d}\!.5914264\ E$$

where E is the number of cycles elapsed since the minimum whose epoch is given by the first term. Tapia's conclusion was that the period remained constant for 17 years.

Dinescu and Dumitrescu (1970) have determined orbital elements of ε Cr A from Tapia's observations. They have noted a large difference between the radii of the two components, an annular eclipse for the primary minimum and a complete eclipse for the secondary minimum. The first component is a star of spectral class F5 and the second component, cooler, has a spectral class G0. As mentioned above, this W UMa system is an A-type one.

We have observed ε Cr A at the ESO 1 m telescope during the nights of July 2/3 and 3/4, 1982. The period of the system is $14^h.1942336$ and we have a large part of a complete cycle (a 12 hours run centred on the meridian transit). The In Sb photometer was used with a K-band filter (2.2 μm) and γ Cr A was used as a comparison star. The light curve obtained during the first night (of better photometric quality than the second one) is shown in fig. 1, where 140 individual observations are reported. The observed minimum is later than the computed one (O−C = 0.07) when Tapia's elements are used. Since his observations, about 9,200 cycles have elapsed. The derived (O−C) could also be explained by a slight difference ($0^s.7$) on the period:

$$P = 0^d.5914345 \text{ instead of } 0^d.5914264.$$

A light curve was obtained during the second night but it is very difficult, from two observed minima, to determine a precise value of the period. We don't observe a complete eclipse at the secondary minimum, but this fact could be explained by a sky transparency fluctuation which unfortunately occurred during the secondary minimum (the expected minimum is shown in figure 1 as a dashed line).

The above results emphasize the need of a more complete and accurate monitoring of this bright and interesting system.

Acknowledgements

It is a pleasure to remind the valuable help from the ESO staff on La Silla, especially from Rolando Vega.

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Search for Wolf-Rayet, Carbon and M Stars in External Galaxies with the GRISM/GRENS Technique

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Introduction

Surveying in extended field objects which are recognizable only by their spectral features would be an almost impossible task without instruments having *simultaneously* a wide field and some spectral discrimination capabilities. Monochromatic imaging with colour or interference filters offers such a means, which has been widely used for searching for H II regions and planetary nebulae in the Galaxy and in external galaxies. An alternative method is to use objective prisms or transmission gratings which supply for each object in the field of the telescope a spectrum, usually recorded on a photographic plate. However, the difficulties involved in manufacturing very large gratings or prisms, limit this method to telescope diameters of about 1 metre, the approximate size of the largest existing Schmidt telescopes. Fortunately, there is a variant of this set-up adapted to larger telescopes, in which a prism, or a grating, or a combination of both is inserted in the converging lightbeam at a short distance of the focal plane. These devices, usually fitted on the prime focus adapter, are called GRISMs or GRENSes. A GRISM combines a transmission grating and a prism with opposed dispersion to compensate the aberrations (coma, astigmatism and field curvature) produced by the grating in the convergent beam, and is associated with a wide-field corrector. A GRENS has a grating grooved on one face of the last lens of a wide field corrector, and also has minimal aberrations. Both are blazed such that most of the light is concentrated in the first order. The GRISM technique has already been widely used to search for quasars through their emission lines, mainly at the Cerro Tololo Inter-American Observatory (Hoag and Smith, 1977, *Astrophysical Journal* **217**, 362; Osmer, 1982, *Astrophys. J.* **253**, 28), and at La Silla for the detection of carbon and M stars in nearby galaxies (Westerlund, *The Messenger* No. 19, December 1979, p. 7).

From a preliminary study of the statistics of Wolf-Rayet (WR) stars, M supergiants and blue massive stars in our Galaxy at different distances from the centre, and in the Magellanic Clouds where systematic WR surveys have been made most recently by Azzopardi and Breysacher (1979, *Astronomy and Astrophysics.* **75**, 120, 243; 1980, *Astron. Astrophys. Suppl.* **39**, 19), Maeder, Lequeux and Azzopardi (1980, *Astron. Astrophys.* **90**, L 17) concluded that the WR/M number ratio decreases very fast with decreasing heavy element abundance, while the ratio (WR + M)/(blue massive stars) remains roughly constant. This can be explained in the following way: amongst the various scenarios which can lead to the formation of WR stars, one seems dominant for stars of initial masses 20–60 $M_{\odot}$ (Maeder, 1982, *Astron. Astrophys.*, **105**, 149). These stars, after having exhausted hydrogen in their cores, move to the right of the Hertzsprung-Russell diagram and become red supergiants. In the absence of mass loss they would stay there until they explode as supernovae. However, mass loss at the different stages of their evolution may be such that the hydrogen envelope disappears completely at some stage, having a star whose surface is mainly composed of helium, with a lot of ^{14}N produced by the previous CNO cycle: the star has become a Wolf-Rayet of the WN type. Further mass loss may peel of the star still deeper until the carbon fabricated by the 3 $^4He \rightarrow {}^{12}C$ reaction appears at the surface: the star is now a WC. The star may end its life as a supernova at any of these stages (the evolution of the core is independent from what happens to the outer parts of the star). If the mass loss at *any* stage is large, the star has a good chance of reaching the WR stage before exploding and will not stay long as a M supergiant. The most massive stars will even by-pass the M supergiant stage. Since mass loss is likely to increase with metallicity, we expect more WR stars and less M supergiants at high metallicities, just as observed. The ratio (WR + M)/(blue massive stars) is roughly equal to the ratio of the duration of the helium burning phase to that of the hydrogen burning phase and does not depend on mass loss in a first approximation, as observed.

Stimulated by the agreement between theoretical ideas and observations, a collaboration was set up between Marc

Azzopardi (Marseille), André Maeder (Genève), Bengt Westerlund (Uppsala) and us in order to survey other galaxies for WR stars; we use the GRISM/GRENS technique applied to the detection of the WR typical strong emission features from either CIII at 4650 Å (WC) or HeII at 4686 Å (WN). We soon realized that this spectral range is also very favourable for detecting carbon stars and M stars, and we are also searching for these objects, extending previous searches with the red ESO GRISM.

The GRISM/GRENS Technique

As said above, one could think of two different techniques to search for WR stars. The first one was used with success as early as 1972 for searching for WR stars in the nearby galaxy M 33 (Wray and Corso, 1972, *Astrophys. J.* **172,** 577). It consists in blinking two plates, one taken through an interference filter centred on a relatively line-free region and one taken through a narrow filter whose bandpass includes the strong λ 4686 and λ 4650 emission lines. This technique is presently used by Shara and Moffat (1982, IAU Symp. No. 99, 531) and by Massey and Conti (1983, *Astrophys. J.,* in press). In principle it has the advantage of being less sensitive to crowding, background and seeing than the second method, the GRISM/GRENS method. However, our experience shows that, using a limited spectral range of about 1000 Å, the first two problems are very minor, while the sensitivity of both methods is comparable. As an important bonus the GRISM/GRENS technique allows us to detect other objects than WR stars: carbon and M stars show up via their absorption bands and small HII regions and planetary nebulae are seen through the emission of H_β and of [OIII] at 4959 and 5007 Å.

At ESO, we have used a blue GRISM mounted on the triplet corrector at the prime focus of the 3.6 m telescope; this set-up has the following characteristics: field of view: 1 degree; blaze wavelength: 4900 Å; dispersion: 2200 Å/mm; grooves: 35/mm; spectral range: 4400–5400 Å, limited by a GG 435 filter and the response of the IIIa-J emulsion.

As shown by fig. 1 the efficiency in the first order is excellent in our wavelength range. On the plates, the zero order image appears as a dot for bright stars only and gives no trouble in practice. The transmission curve for the GRISM was established using the universal spectrophotometer of the optical laboratory at ESO Garching. We also used the green GRENS at the prime focus of the CFH telescope, which has almost identical characteristics. The limiting magnitude for detection of the continuum is about 20 in a 1-hour exposure with average-to-good seeing. Some WR star candidates with a fainter continuum appear as isolated dots if only the line emission is above the plate threshold; they have to be confirmed by further spectroscopic observations.

Wolf-Rayet and Carbon Stars in the Magellanic Clouds

We have obtained GRISM plates of two fields in the LMC and most of the SMC with the 3.6 m ESO telescope, with various exposure times. The aim was to test the method, but also to check to what extent the previous surveys of WR stars made by objective-prism techniques are complete. We have so far not discovered any new WR stars down to magnitudes 19–20, confirming the completeness of these surveys, at least in the regions explored. This is at variance with the suggestion by Massey and Conti (1983, *Astrophys. J.* 264, 126) that in the Magellanic Clouds not all of the WR stars with $M_v > -2$ have been detected (we except from this discussion the much fainter WR "objects" which are nuclei of planetary nebulae). This

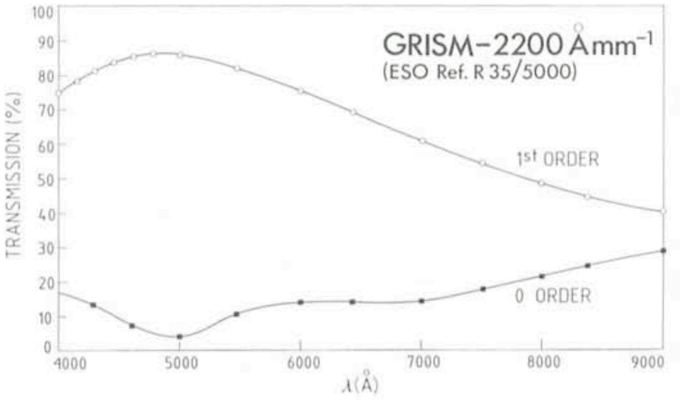

Fig. 1: *Curves showing the efficiency as a function of λ of the blue GRISM used with the triplet corrector at the prime focus of the ESO 3.6 m telescope.*

makes us confident that we can eventually obtain complete samples of WR stars in more distant galaxies.

As a bonus of the technique, we have detected a large number of planetary nebulae, M stars and carbon stars. Identification of these objects with those catalogued previously is under way, but is time-consuming because of their large number: we estimate that we have something like 200–300 carbon stars per square degree in the central parts of the SMC!

Wolf-Rayet Stars in NGC 6822 and IC 1613

We have now ESO GRISM plates and CFH GRENS plates of several galaxies of the Local Group and of the Sculptor Group. Many emission-line candidates can be seen on those plates, but they can be either WR stars characterized by the λ 4650 CIII or the λ 4686 HeII emissions, or HII regions (or planetary nebulae) emitting mainly around 5007 Å. It is not possible to distinguish between these objects when the continuum is invisible: further spectroscopy is necessary, in any way also for classifying the WR stars. We obtained time at the ESO 3.6 m telescope with the IDS to carry out spectroscopy of the most promising candidates. Unfortunately the weather was not on our side and only a limited number of observations could be made. The WR nature of one star in the dwarf irregular galaxy NGC 6822 could nevertheless be confirmed (fig. 2). This is a 19.5 mag star in an association and a weak H II region, and it is classified WN3 (Westerlund, Azzopardi, Breysacher and Lequeux, 1983, *Astron. Astrophys.,* in press). Its absolute magnitude is $M_v \sim -4.6$, which agrees well with the values found for WN3 stars in the LMC. There is another promising WR candidate on our GRISM survey plate. From what we know of the stellar content and the metallicity of NGC 6822, we can predict the existence of 1 or 2 WR stars in this galaxy. Therefore, the agreement is satisfactory within the limits of the small-number statistics.

We have also good CFH GRENS plates of the dwarf irregular IC 1613, another nearby member of the Local Group. A cursory examination shows no other candidate than the peculiar WR star of $M_B \geq -5$ (fig. 3) discovered by D'Odorico and Rosa (1982, *Astron. Astrophys.* **105,** 410). This is not unexpected since we predict (statistically) 0.7 WR in this galaxy! However, our plates show the presence of many carbon stars which deserve further study.

Carbon Stars in the Fornax Dwarf Elliptical Galaxy

The presence of carbon stars in this galaxy is well established by a number of recent studies (see Westerlund, *The Messenger* No. 19, December 1979, p. 7; Richer and Wester-

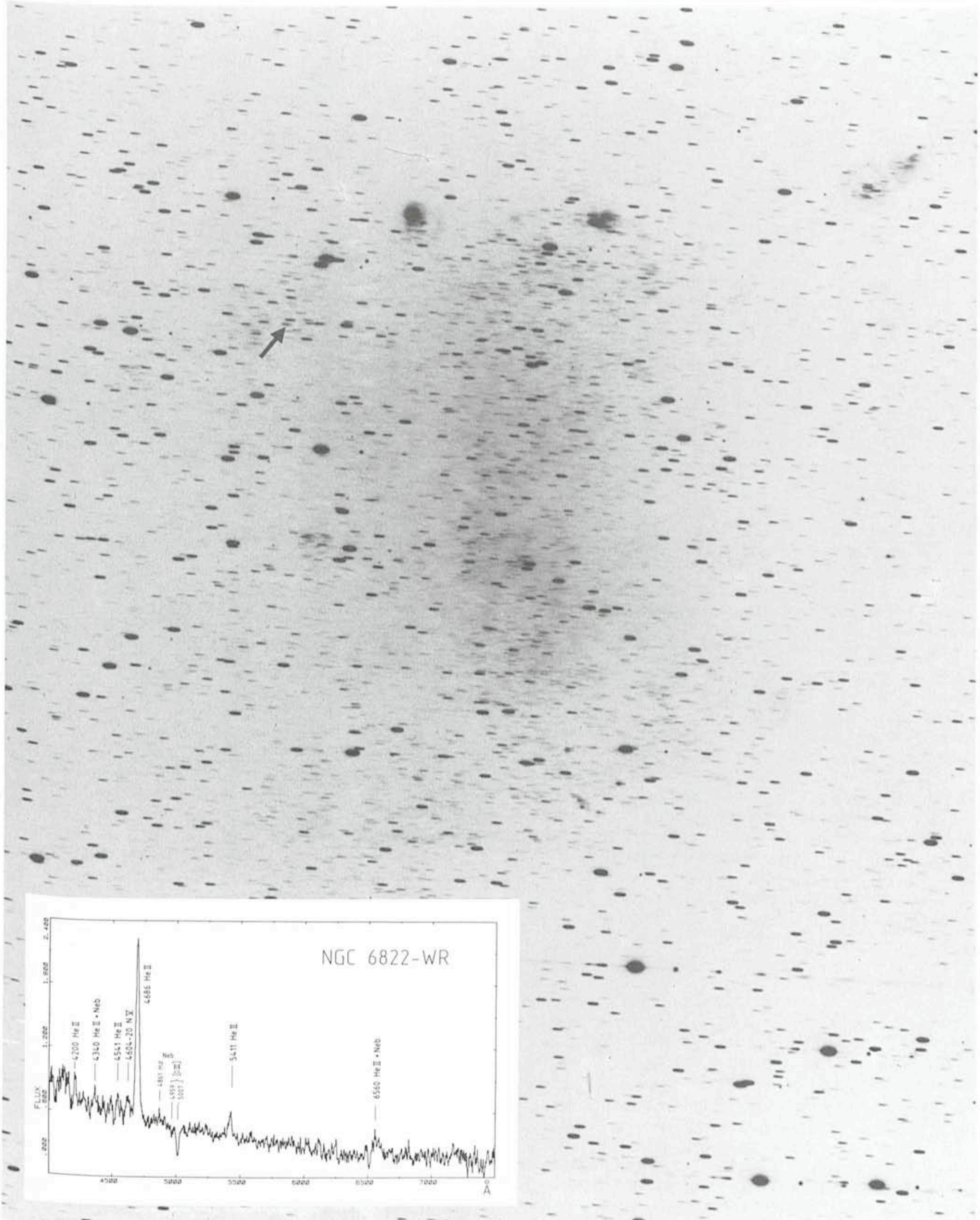

Fig. 2: *A 90-min. exposure of the galaxy NGC 6822 obtained with the blue ESO GRISM at the prime focus of the 3.6 m telescope. The first WR star discovered in this galaxy is indicated by an arrow. The spectral type derived from the IDS spectrum is WN3.*

lund, 1983, *Astrophys. J.* **264,** 114). The very presence of carbon stars whose progenitors are relatively massive and thus cannot be very old, shows that the Fornax galaxy, in spite of being presently completely deprived of interstellar gas, has managed to form stars only a few thousand million years ago. Carbon stars appear more readily in galaxies of low metallicity, simply because carbon dredge-up episodes during the evolution on the asymptotic branch raise more easily the C/O ratio

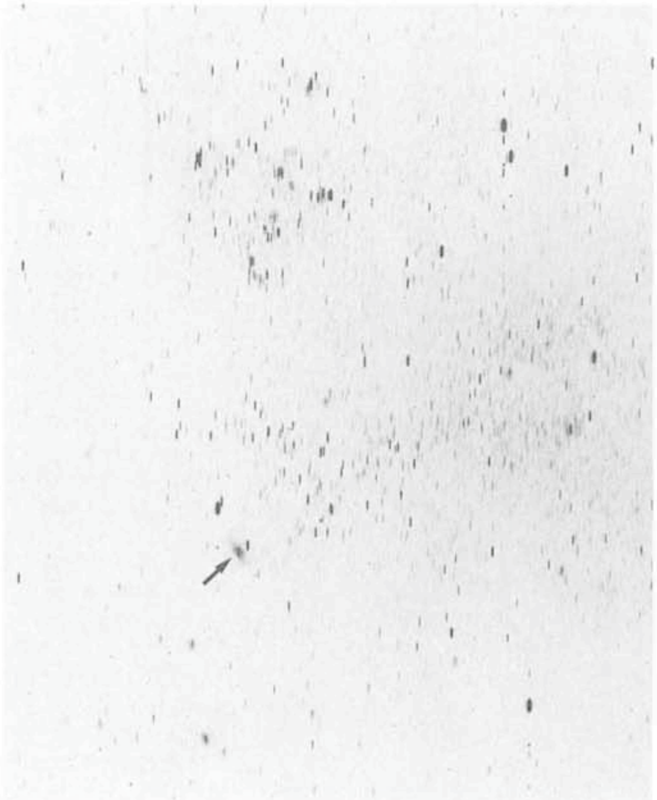

Fig. 3: *CFHT green GRENS photograph of the eastern part of IC 1613. The spectrum indicated by an arrow corresponds to the peculiar WR star discovered in this galaxy by D'Odorico and Rosa (1982).*

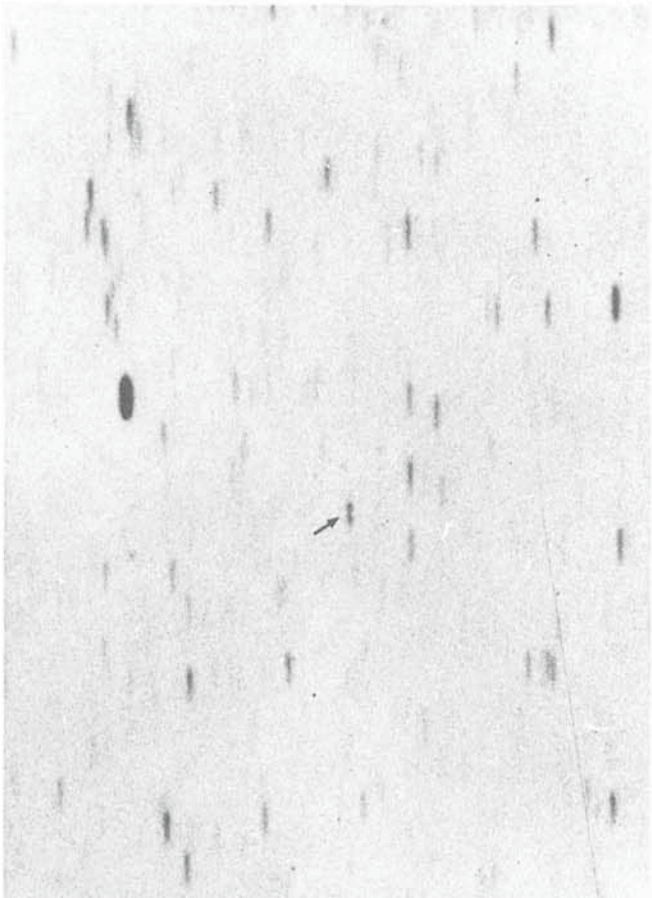

Fig. 4: *Part of a CFHT green GRENS plate of the Fornax dwarf elliptical galaxy. The spectrum marked with an arrow corresponds to a newly identified carbon star. Previously known as DK 36 this star has V = 18.40 and B-V = 2.09 (Demers and Kunkel, 1979,* PASP ***91,*** *761).*

above unity (the definition of a carbon star) when the oxygen abundance is low; the large number of carbon stars we find in the Fornax galaxy shows that its metallicity must have been rather low at the time of their formation. As discussed by Iben and Renzini (1983, *Ann. Rev. Astron. Astrophys.*, in press) everything is very far from clear in our detailed understanding of the evolution of carbon stars: this is one further reason to study them in as many galaxies as possible. Using the red ESO GRISM, Richer and Westerlund (1983, *Astrophys. J.* **264,** 114) were able to raise the number of known carbon stars in the Fornax galaxy to 49 and estimate their total number as about 65; they also discovered 1 new carbon star in the Sculptor dwarf elliptical galaxy which is now known to contain 3 such stars. In Fornax, Westerlund also found a rare S star – the intermediate class between M and C stars (Westerlund, 1983, *Astron. Astrophys.* **118,** L5).

We obtained a 1-hour green GRENS plate of the Fornax dwarf elliptical galaxy at the CFH telescope. This plate shows an incredible number of objects with absorption bands, of the order of 300. Most of them appear to be carbon stars (fig. 4), thus the actual number of the latter objects is probably far above the predictions by Richer and Westerlund. It may be that our IIIa-J plates allow the detection of a hotter type of carbon star than identified on the near-infrared plates. This looks very exciting, but must be confirmed by further GRISM/GRENS and spectroscopic observations.

Towards More Distant Galaxies

Finding WR and carbon stars in more distant galaxies becomes increasingly more difficult. Prime targets are M 33 and various galaxies of the Local Group and of the Sculptor Group. We are presently looking hard at those galaxies.

On a 1-hour CFHT plate of M 33 we see about the same number of emission-line objects as described by Massey and Conti (1983, *Astrophys. J.*, in press) who used the filter technique – but not quite the same objects: this illustrates that the two techniques are more complementary than competing. However, both groups are probably still far from having detected the 200 or so WR stars that we predict to exist in M 33. M 31, in which 17 WR stars have been found by Shara and Moffat (1983, *Astrophys. J.*, in press) is even more difficult because this galaxy is seen more edge-on and has more internal extinction than M 33.

The GRISM plates obtained at the ESO 3.6 metre telescope for the galaxies NGC 55 and NGC 300 of the Sculptor Group have revealed 115 emission-line objects for which slit spectroscopy is now under way. Concerning NGC 300, a recent spectroscopic survey of continuum emission from 16 giant H II regions, by D'Odorico, Rosa and Wampler (ESO preprint No. 243, April 1983), resulted in the detection of WR stars in two regions. WR features were also identified in the spectra of 2 H II regions out of the 6 surveyed in NGC 5457.

Complete sampling of WR stars in more distant galaxies would be beyond the possibilities of the techniques we use presently. However, bigger telescopes and/or more sophisticated detectors could enlarge the range of such searches in a not-too-distant future.

Acknowledgement

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A Puzzling Object: V 348 Sgr

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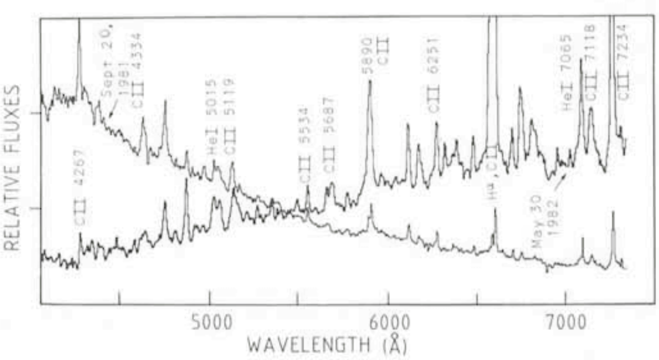
V 348 Sagitarii is one of the many variables discovered by Miss Ida Woods on Harvard plates *(Harvard Bulletin* 838, 1926). Later, in the 1950s, 500 patrol plates have been scrutinized by Mrs. Jean Hales Anderson (Hoffleit, *Astronomical Journal,* **63,** 78, 1958) at Maria Mitchell Observatory. This material covered the period 1906–1939 and the derived light curve suggested a semi-regular variability with cycles of 200 to 400 days. Because of the resemblance of its light curve with the ones of stars undergoing at irregular intervals sudden drops of brightness before recovering more slowly their previous magnitude, that star was once classified as belonging to the R Coronae Borealis type by Schjan, who rediscovered the star in 1929 and gave it the number 3976 in the H(amburg) V(ariables) catalogue *(Astronomische Nachrichten,* **235,** 417, 1929). V 348 Sgr, however, is seen more often at minimum light than at maximum, contrarily to the R Coronae Borealis stars. These objects are known to be carbon rich and this is indeed the case for V 348 Sgr; however, as shown first by George Herbig *(Astrophysical Journal,* **127,** 312, 1958) the spectrum, unlike the other stars of the type reveals the presence of a hot diluted atmosphere around the star where many lines of ionized atoms of carbon are seen instead of absorption bands due to molecular compounds. So both by its light curve and by its spectrum V 348 Sgr is indeed a peculiar object.

In 1960, I happened to sail to California with plates of this star obtained in 1958 by J.L. Greenstein at Palomar. The spectra had been measured in Liège by a student. Looking at them, I was struck by the very peculiar line profiles and I decided to record them with the at that time newly designed intensitometer at Caltech, before handing them back to the custodian of the famous plate vault at Mount Wilson offices. Some time later, while staying at Harvard College Observatory, I had a casual discussion with Cecilia Payne Gaposhkin who stressed the uniqueness of the characteristics of the object. I went back to my tracings and indeed more and more peculiarities showed up; for instance, Herbig mentioned the presence of numerous emission lines: there were indeed quite a few pure emission lines but I noticed that many of them were flanked by an absorption component on their violet side, a rather unusual feature. Moreover certain emission lines appeared as double. When looking at the atomic levels implied I noticed that the double lines arose from levels due to configurations with one electron excited. Other ionized carbon lines were either of the "inverted P Cygni" type or single emissions.

This was the situation in 1968, when I decided to obtain more information both on the photometric and spectroscopic behaviour of this puzzling object. But in Europe the observing season for a star never brighter than the 11th magnitude and located at 23 degrees of southern declination in the summer sky is rather short. Furthermore, with the equipment available at that time, spectra could be obtained successfully only at light maxima. The latter could not be foreseen and some years the star remained stubbornly at minimum for the whole summer. I was fortunate to meet at that time M. Duruy, a very active observer of variable stars near Nice, who kindly accepted to put the object on his rather crowded observing programme. Already during the 1970 campaign, he succeeded in making visual estimates of the star's brightness and immediately noticed that its light curve had no resemblance with any of the numerous variables on his list. *(Bull. Soc. R. Sc, Lg,* **39,** 600, 1970). He was warning me when a light maximum was on the way and this permitted Mrs. Andrillat and myself to obtain a first spectrum in the one-micron region, which, despite bad observing conditions, exhibited the He I λ 10830 line in emission (1971). When the possibility appeared of obtaining spectra of weak sources in the ultraviolet, I applied for time at the IUE. In order to have some chance of success because of the nature of the observations ("on alert") and the unavoidable conflicts with a crowded schedule, it was almost indispensable to obtain the complicity of an astronomer right at the observing ground station. I got my former student André Heck interested in the project. But we entered a period when the star did not want to cooperate in remaining desperately faint for months and months. In the meantime the patrol was continuing both by M. Duruy and his associate in Tahiti (and later by M. Verdenet *[Bull. AFOEV,* **18,** 33, 1981 and **19,** 33, 1982]), and with the Liège-CNRS Schmidt telescope at Haute-Provence. At ESO, a much better location, H. Debehogne from Uccle started taking plates with the GPO astrograph and observed a drop of more than four magnitudes from April 22 to 26, 1979. In the meantime, a few nights were obtained on the ESO spectrographic telescope, with bad luck with the weather. Finally in August 1981, as André Heck was observing at La Silla, the star suddenly fainted from the 12th to fainter than the 17th magnitude in six days. So the hope to observe it with the IUE during the allotted time in September vanished once more and we were again in a sad mood when we heard from F. Bateson in New Zealand that the star had recovered to a magnitude of 12.2 and remained apparently stable. The IUE telescope could then be pointed towards the object and a weak noisy spectrum was obtained.

Because of the nature of the spectrum with dozens and dozens of bright lines I expected a spectrum showing emissions of several carbon ions like in Wolf-Rayet stars or in planetary nebulae. Actually, the noisy spectrum was quite disappointing, showing besides an enormous continuum absorption feature around 2250 Å ill-defined absorptions at 1550 Å (C IV) and 1335 Å (C II) together with some lines of Si III and possibly the interstellar Mg II line at 2800 Å. M.P. Véron obtained shortly later at the ESO 1.5 m telescope a



ESO IDS spectra of V 348 Sgr. The spectrum labelled "Sept 20, 1981" has been obtained by M.P. Véron with the 1.5 m telescope at maximum light. The continuous spectrum strongly decreases with increasing wavelength. The strongest lines belong to C II, He I and [NII] (blended with H_α). The spectrum labelled "May 30, 1982" was taken by M. Pakull at the 3.6 m telescope, when the star was about magnitude 17. The 224 Å/mm reciprocal dispersion permits to see an important change in the emission line intensities compared to the continuum. The blend around H_α is quite conspicuous, as already noted by Herbig (Astrophys. J. **127,** *312, 1958). Spectra calibrated by A. Heck.*

spectrum with the image dissector scanner which displayed features similar to the ones of the Palomar spectra of 1958, also taken at maximum. In the meantime, infrared photometry had been obtained by Feast and Glass in South Africa *(Monthly Notices of the Royal Astronomical Society,* **161,** 293, 1973) and by Webster and Glass *(M.N.R.A.S.,* **166,** 491, 1974), which indicated that the star was both a strong and variable infrared emitter. At minimum light, the only spectrum described is the one mentioned by Herbig *(Astrophys. J.,* **127,** 312, 1958). It shows typical lines seen in the spectra of planetary nebulae ([OII], [NII], [SII]), but no carbon line in the usual wavelength range. An interesting optical spectrum was obtained by M. Pakull at ESO on May 30, 1982 when the star was becoming very faint. It shows a very different spectrum from the spectrum at maximum. C II lines are stronger with respect to the continuum (see figure), which itself has an opposite slope with respect to the energy distribution at maximum light, fairly typical of a B-type star. All these data are presently being analysed in collaboration with U. Heber (Kiel).

This object clearly deserves more attention, and observations (filter photographs, photometry and spectrometry) at various phases and in a wide energy range will be necessary before we understand the nature of this hot carbon star and its possible association with a neighbouring nebula. A possible model is the one of a moderately hot object surrounded by nebular material. Temporary but substantial ejection of gas leads to the formation of dust by condensation at high altitude and the star is obscured, while the infrared emission is strong. When the matter falls towards the central star, dust evaporates, due to the increasing temperature, and we see the infalling material as ionized carbon, giving rise to "inverted" P-Cygni profiles. At that phase the extension of the envelope is small and its volume emission in the lines is weak compared to the continuous photospheric emission. Therefore we do not see emission lines in the ultraviolet, but in contrast the emission lines appear in the visible and in the infrared where the photospheric emission is much weaker. This could be a qualitative model for the behaviour of this star, but many features remain to be explained and as Webster and Glass mention in the conclusion of their paper *(M.N.R.A.S.,* **166,** 451, 1974) "V 348 Sgr has something important to tell us" about stars at this stage of their evolution.

A New Guider for the ESO 1 m Schmidt Telescope

W. Eckert and A. Muller, ESO

Introduction

A new guider for the ESO 1 m Schmidt telescope was installed inside the telescope tube in June-July 1982. After about one year experience one can say that the system has proved to be very efficient. This device may be useful for other Schmidt telescopes where long exposures are hampered by guiding problems. Historically, the ESO Schmidt was equipped with two guiding telescopes of 20 cm diameter and 300 cm focal length. However, differential flexure between guiders and camera made long exposures impossible. Only a one-hour exposure, symmetrical with respect to the observer's meridian and using a low resolution 103 a-O or II a-O emulsion, was the very best one could obtain. To improve guiding conditions, two off-set guiders were constructed in succession and each one was used for a sufficiently long time to learn the requirements for an efficient off-set system. The new guider has its guide probe in the observer's meridian and at the North edge of the photographic plate. At this position the corrector plate is not vignetted by the main mirror's edge.

Compared with the 20 cm guiders there is a light gain of 3 magnitudes. An acquisition area of 0.071 square degree is available. In small field mode stars of $14^{m}.2$ are detectable and guiding, although with some effort, can be done on a 13th magnitude star. At the galactic pole 1.7 stars $\leq$ 13 m per 0.071 square degree can be acquired and at the Galactic equator 14 (Allen, *Astrophysical Quantities,* page 243). So star acquisition gives no problems.

In order to ensure a differential flexure-free link between guider and photographic plate, all optical parts of the guider between the guide probe and the cross wire are mounted as one strong unit on top of the North surface of the plate holder support device. The optics, imaging crosswire and star on the television camera detector are partly mounted on the tube wall because, for this part, differential flexure bears no consequences for perfect guiding.

With the 4-degree objective prism mounted, the guider sees spectra just as the photographic plate. These spectra are useless for guiding. Therefore, a two-prism system can be activated reducing the guide probe spectra into star images. This reduction can only be performed with the prisms placed in a parallel beam. So two objectives are used, the first one making the star beam parallel and the second one imaging the star on the cross wire. To avoid too large refracting angles for the prisms the focal length of the second objective must be not less than 600 mm. As a consequence the optical path between guide star and cross wire is so large that the beam must be folded within the area of the north surface of the plate holder support. This is achieved by introducing six mirrors. Two more mirrors are used to project guide star and cross wire on the television camera detector.

As the spectral dispersion of the objective prism must be in the direction of the declination, to obtain the best quality spectral plates, and the dispersion of the compensating prisms must be perpendicular to the declination direction, for reasons of mechanical stability, the spectra in the guide probe must be rotated over 90 degrees before they reach the compensating prisms. This rotation is achieved by a three mirror system in front of the first objective. In total eleven flat mirrors form part of the guider. At a reflexion angle of 45 degrees 87 % of the light is reflected. Therefore, the mirror system causes a light loss of about 1.7 magnitudes. To this should be added a light loss of about 0.2 magnitude due to the coated objectives. This loss of about 1.9 magnitudes is already taken into account in the limiting magnitude discussed above. All flat mirrors, except the first 3, have an accuracy of $\lambda/10$ and the first three $\lambda/5$. For long exposures and for declinations South of –50° the differential refraction between plate centre and guider is corrected by an electronic cross. (See Muller, *Abhandlungen der Hamburger Sternwarte,* Band X, Heft 2, 79.)

Mechanical Description of the Schmidt Guider

Fig. 1 shows, inside the indicated ellipse, the location of the guider, and fig. 2 the detailed outlay of the optical parts. Mode

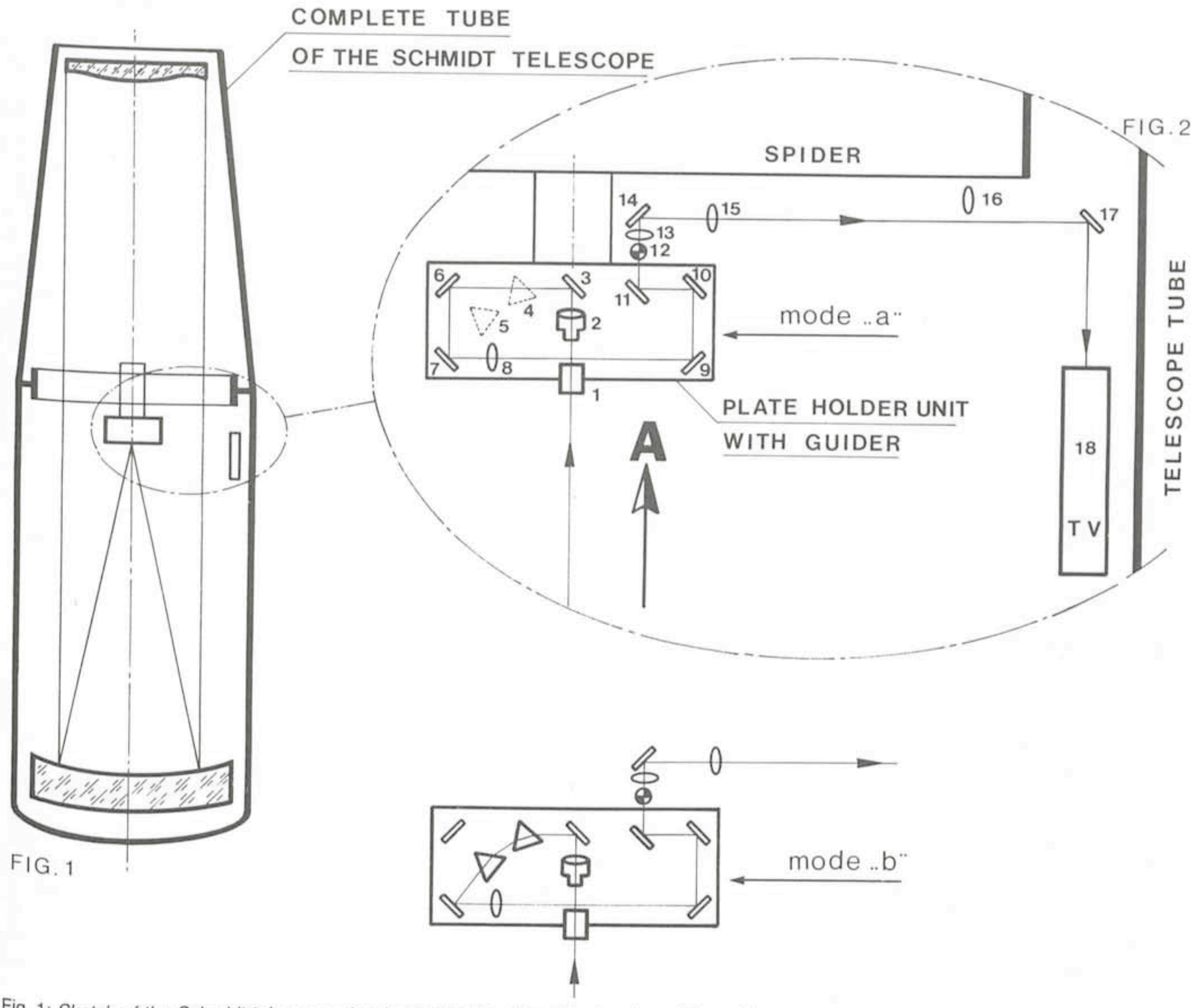


Fig. 1: *Sketch of the Schmidt telescope showing inside the ellipse the location of the guider.*

Fig. 2: *Detailed outlay of the optical parts of the guider. Mode "a", or "direct vision mode", is used for direct photography; mode "b", or "prism mode", when the objective prism is mounted; in this case, prisms 4 and 5 reduce the guide star spectrum into a starlike image.*

"a" is called the "direct vision mode" and mode "b" the "prism mode". Fig. 3 gives a top view of that part of the guider which is mounted on top of the plate holder support. The light enters through subassembly 1. This part consists of 3 mirrors causing the rotation of the guide field over 90 degrees. A drawing of this part is shown in fig. 4. The indicated light direction in fig. 4 is from the main mirror to the first guider objective. This objective is mounted on the subassembly 2 and is an F/2 Canon objective with a focal distance of 85 mm, producing a parallel beam along the paths 3, 4, 5, 7, 8 and 3, 6, 7, 8. The subassembly 2 has three degrees of freedom i.e. X and Y motion for star acquisition and Z motion for focusing with ranges of ± 5 mm. The bearings are completely free of backlash and clearance in the spindles is compensated by tension springs. The X, Y and Z positions are controlled by inductive gauge heads with 10 mm stroke and a setting accuracy of 5 microns. The gauge head controlling the Z position is clearly visible in fig. 3.

Part 3 is a fixed mounted flat mirror reflecting the parallel beam at an angle of 90 degrees with respect to the entering beam. After this reflexion, the observer can choose one of the

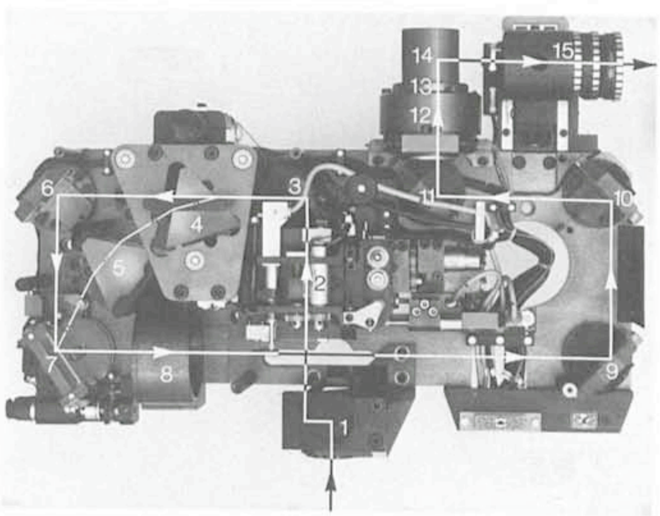


Fig. 3: *Top view of the part of the guider which is mounted on top of the plate holder support, with the light path indicated.*

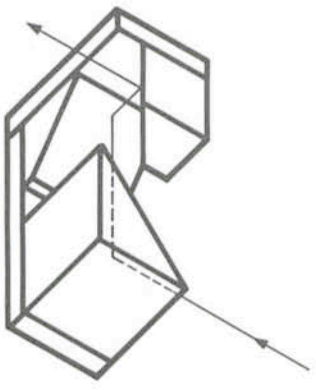


Fig. 4: *Drawing of subassembly 1 which consists of three mirrors producing a 90° rotation of the guide field.*

two modes "a" or "b" mentioned above. In mode "a" the beam passes underneath the upwards lifted prism 4 and goes to a fixed mirror 6 where it is reflected towards mirror 7. Mirror 7 reflects the parallel beam in the direction of the optical axis of objective 8. In mode "b" prism 4 is moved downwards into the parallel beam which now passes the prisms 4 and 5 and, when reaching mirror 7, is reflected in the direction of the optical axis of objective 8.

To achieve the same reflected direction for the beam coming either from mirror 6 or from prism 5, mirror 7 is made rotatable over a fixed angle and its position is commanded by the position of prism 4. The rotating table on which mirror 7 is mounted is clearly visible in fig. 3.

The second objective 8 has a focal length of 600 mm and a diameter of 60 mm. From this objective onwards there exists only one mode in which the imaging beam is reflected by the fixed mirrors 9, 10 and 11 to the cross wire device located at subassembly 12. Each wire of the cross is double and made of two strained quartz fibers, 30 microns in diameter and 300 microns apart, defining in the guide field a square of 2.9 × 2.9 arcsec square. The wires are illuminated by four LEDs positioned diagonally with respect to the cross.

The subassembly 13 holds a field lens with 250 mm focal length and 30 mm diameter.

The subassembly 14 contains a fixed mirror reflecting the guide beam to the tube wall. Here again the observer can choose between two modes, namely large field or small field mode.

Choosing small field mode, the subassembly 15 moves into the beam. This subassembly can support four different objectives with focal lengths of 140, 160, 180 and 200 mm and 30 mm diameter. Exchange of objectives is manual and can only be done when the telescope is in plate loading position.

Choosing large field mode, subassembly 15 moves outside the beam and objective 16 moves into the beam. This objective has a focal length of 200 mm and a diameter of 50 mm. It is mounted on a rotating arm which is attached to the tube wall. Changing the field modes takes 5 seconds.

Finally the beam is reflected by mirror 17 to the television camera 18.

The visible field on the monitor is for the large field, which fits completely within the monitor screen, 251 × 258 arcsec square and for the small field, where the dimensions of the monitor screens set the limits, 109 × 96 arcsec square for the 180 mm objective.

Except for the exchange of the four small field objectives all other functions are remote controlled from the observer's room.

The total weight of the guider unit shown in fig. 3 is 9 kg and it is accurately balanced to avoid spider rotation.

Except for the optical parts 1, 2, 4 and 5, all optics were purchased from Spindler and Hoyer, Göttingen. The objective 2 was bought in the local market. The optical parts 1, 4 and 5 were purchased from Horst Kaufmann, Crailsheim.

We would like to mention that all mechanical parts of this guider were manufactured by our mechanics in the Astro-Workshop at La Silla under the supervision of Jorge Díaz and Walter Vanhauwaert.

The electronic circuitry was designed by Rolando Medina of the T.R.S. and installed by him and his collaborators.

We also would like to thank Francis Franza and Maurice Le Luyer for their support during the design development of the optical parts 1, 4 and 5.

For technical information or drawings contact W. Eckert.

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

FINGER, Gert (A), Infrared Instrumentation Engineer, 11.7.1983
DE SCHOUWER, Marc (B), Administrative Assistant (Accounting), 19.9.1983

Chile

GRANBOM, Sven (S), Head of operations, 1.10.1983

Departures

Europe

KLIM, Klaus (DK), Electronics Engineer, 30.9.1983
LJUNG, Bo (S), Electronics Engineer, 30.11.1983

Chile

EICHENDORF, Walter (D), Astronomer, 30.6.1983
ARDEBERG, Arne (S), Director at La Silla, 23.10.1983
NERI, René (F), Electro-mechanical Engineer, 31.12.1983

FELLOWS

Departures

Europe

BJÖRNSSON, Clæs-Ingvar (S), 30.9.1983
MOUCHET, Martine (F), 30.9.1983
SVENSSON, Roland (S), 30.9.1983
WOUTERLOOT, Jan (NL), 30.9.1983

ASSOCIATES

Arrivals

Europe

IYE, Masanori (Japanese), 1.9.1983
WILLIAMS, Robert (USA), 1.9.1983
AZZOPARDI, Marc (F), 1.10.1983

Departures

Europe

FREDRICK, Laurence (USA), 31.7.1983
LUCY, Leon (GB), 31.8.1983
SALVATI, Marco (I), 30.9.1983

First Test of the New Spectrophotometer Devoted to Stellar Seismology

E. Fossat, Observatoire de Nice, and
Y. Decanini and G. Grec, Département d'Astrophysique de l'I.M.S.P., Nice

Solar seismology (or helioseismology) was born in 1975. Since that recent date it provided the first unambiguous information regarding the internal structure of the sun.

The resulting recrudescence of astronomers' interest for solar physics coincides, and this is not by chance, with the one due to uncertain and controversial results obtained in measuring the neutrino flux and the solar oblateness. It could be necessary to question either some aspects of elementary particle physics or the theory of stellar evolution. The consequences of this last possibility over all astrophysics explain why the importance of solar seismology has quickly become much broader than the frame of solar or even stellar physics.

Since 1975, our group has specialized in this solar programme. Radial and low-degree solar pulsations are detected by means of the Doppler shift measured with a sodium optical resonance spectrophotometer. The sun is observed in integrated light, "like a star". A major step has been crossed by using this instrument at the Geographic South Pole. Down there, it was possible to obtain continuous data over more than five days. This made possible the identification of over 80 solar acoustic eigen modes (Grec et al., 1983). Their Doppler amplitudes are from 2 to 25 cm s^{-1} and their periods in the five-minute range corresponding to relatively high order overtones (12–34) of radial and low degree ($l \leq 3$) modes. Typically the frequency distribution of power (obtained by Fourier analysis) displays a discrete pattern of almost equidistant peaks around 3 millihertz. They are separated by 68 microhertz and correspond to successive overtones of alternately even and odd degree modes. (See Grec et al., 1983.)

The small but significant discrepancy between these measured frequencies and the corresponding ones calculated with various solar models (Rhodes and Ulrich, 1983) has urged solar astronomers to get more information in order to probe more accurately the deeper layers of the sun's interior. At the same time, and taking into account the fact that the sun was observed "as a star" it was decided to start the same kind of observation on other stars, in order to broaden the field of comparison between observation and theoretical calculations.

Measuring Doppler shift fluctuations of a few cm/s on a star is a highly difficult task. For evident reasons of flux difference, we could not use the same instrument for observing the sun and for observing stars. Consequently, a new specialized spectrophotometer was designed and built in our laboratory (Fossat et al., 1982). Optimized in photon efficiency, its principle is to measure Doppler shift fluctuations through changes of the monochromatic intensity in a wing of the Na D1 sodium absorption line in the stellar spectrum. The monochromatic filter is an optical resonance sodium cell between two crossed polarizers. In a permanent axial magnetic field, both the absorption of a circular polarization and the rotation of the linear polarization are acting and result in the transmission of a 0.08 Å bandwidth centred on the laboratory wavelength of Na D1. It is then shifted on the adequate portion of the stellar line wing by using the combined effects of the stellar radial velocity and the orbital motion of the earth.

Such a filter has altogether an absolute spectral stability (the sodium atoms themselves decide of the transmission wavelength) and a very high transmission.

Typically the slope of the D1 sodium line wing is of the order of 10^{-4} (in relative value) per m s^{-1}. The relative fluctuation of intensity measured through the filter will then be of about $2\ 10^{-5}$ for an 20 cm s^{-1} amplitude oscillation. Provided the time series are long enough for separating the successive peaks in the Fourier analysis, the photon noise will be beaten down to this level if the total number of integrated photons is about $1/(2.10^{-5})^2 = 2.5\ 10^9$.

A counting rate of a few 10^4 per second can do the job if a few nights of integration can be obtained. Extrapolating our personal experience with the sun indicated that such a value could be obtained by using the largest available telescopes to observe the brightest stars.

It was decided to test the new instrument on α Centauri, because of the very close similarity of this star with the sun. Seven nights were granted for this programme at the ESO 3.6 m telescope in June 1982. Unfortunately the first five nights remained totally cloudy. The sixth night, we had to stop after just over two hours of recording due to high wind speed. The last one provided 7 hours of data, unfortunately through a non-photometric sky, its transparency fluctuating by 3 to 5%.

The counting rate obtained during this observation was 6×10^3 per second, including about 900 of dark current (photomultiplier dark current and depolarized light from the continuum). Only one night with cirrus clouds was not enough for detecting the stellar oscillations. The detailed analysis (Decanini, 1983) leads to a noise of a few m s^{-1} per point of the Fourier spectrum.

For the continuation of this observing programme we have the following remarks:

– The photon noise estimation made here above is very straightforward. It assumes, for example, that the stellar oscillations have the same amplitude as the solar oscillations, and that they manifest in our filter only through a Doppler shift of the line. Evidently, the amplitude will depend on the star. There are theoretical arguments, namely the balance of energy between convection and oscillations, which indicates that stars somewhat hotter and older than the sun would oscillate with 5 to 10 times more amplitude. (Christensen-Dalsgaard and Frandsen, 1983.) On the other hand, our filter can detect monochromatic changes of intensity in the line wing due not only to Doppler shift (local temperature, sodium ionization . . .)

– The weather will almost necessarily be better than it was during this first test.

– The counting rate can be improved first by broadening the filter bandwidth (100 mÅ, instead of 80, can be obtained with a few more degrees in the sodium cell temperature and a stronger permanent magnet) and mostly by using both D1 and D2 sodium lines.

Just when finishing to write this note, we are coming back from a second observing run granted at the 3.6 m telescope in May 1983. Two and a half very good nights have been efficiently used, with a photon-counting rate of over $3\ 10^{+4}$ per second. The Fourier analysis of this signal remains to be done and will appear in one of the next issues of the *Messenger*. Certainly, oscillations similar to the solar five-minute p-modes are detectable.

Now our spectrophotometer will also have to be used on stars of different types. Following the theoretical arguments already mentioned, the best candidate will be Procyon. In any case we are now on the verge of seeing the birth of seismological investigation of non-variable stars.

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Detection of Highly Ionized N and O in the Infrared Spectrum of Nova Muscae 1983?

E. Oliva and A.F.M. Moorwood, ESO

This bright nova was discovered in January 1983 by Liller (1983, IAU Circular No. 3764), just before our scheduled infrared observing runs at the ESO 3.6 m and 1 m telescopes during which we were able to both monitor it photometrically between 1.2 μm and 10 μm and obtain low resolution 1.4-4.2 μm spectra. A detailed description and analysis of these data will be contained in an extensive paper combining ultraviolet, optical and infrared observations, which is now being prepared mostly by J. Krautter. As, to our knowledge, no previous infrared spectra of novae between 1 μm and 2 μm have been published, we would like to make use of this short article to report the discovery of a strong but broad emission feature at 1.56 μm which we can best explain at the moment as an unresolved group of recombination lines to He II, OV and NV – species normally associated with UV rather than IR spectroscopy.

The 1.45 μm – 1.8 μm spectrum shown in fig. 1 was obtained on Feb. 10 using the InSb CVF spectrophotometer at the ESO 1 m telescope. As expected, it contains the strong hydrogen recombination lines BR_ζ (10-4, 1.736 μm) and BR_η (11-4, 1.681 μm) plus a broad emission region resulting from unresolved hydrogen lines between $Br_{12\text{-}4}$ and the series limit. (Other bracket lines are present in the longer wavelength spectra, e.g., BR_γ (2.17 μ) and Br_α (4.05 μm) and their intensity ratios imply that at this stage the optical depth of the gas to hydrogen lines was intermediate between the optically thin and optically thick limits. Ratios of He II recombination lines on the other hand suggest that the gas was optically thick at the He II transitions. Taken together, these results are consistent with a very steep gas density distribution, as would be expected shortly after the nova outburst.)

The new discovery in fig. 1 is the strong feature at 1.56 μm which, as can be seen by comparison with the hydrogen lines, is broader than the instrumental resolution even though the latter was only R ~ 65. Features of this type, arising in a variety of astronomical objects, are usually attributed to emission bands of molecules in grain mantles. In the present case, however, the nearest known molecular feature is one at 1.53 μm observed in cool, C-rich Mira stars (Goebel et al., 1981, *Astrophysical Journal,* **246,** 455). If the 1.56 μm feature does arise in grain mantles therefore, the molecules responsible have not yet been found in other astronomical situations. The alternative explanation offered here is that this "broad" 1.56 μm feature consists of closely spaced emission lines. In fact, as shown in fig. 2, the feature can be adequately fit with just two lines, whose most probable centre wavelengths are 1.575 μm and 1.557 μm. The former can be identified with He II (13-7, 1.573 μm) and the second with XV (10-9, 1.554 μm) where, because the latter transition is quasi hydrogenic, the element X cannot be uniquely identified on the basis of the infrared spectrum alone. Given the strength of the emission, however, it would appear reasonable on abundance arguments to assume that C, N or O are responsible. Of these, C is essentially excluded by the extremely high (392 eV) ionization potential of CV. Also, the C IV infrared recombination lines,

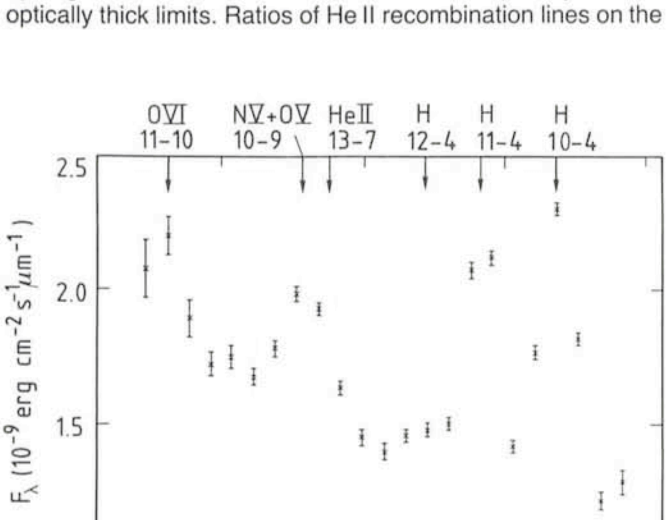

Fig. 1: *1.42–1.80 μm spectrum of Nova Muscae 1983. The intensity scale is in units of 10^{-9} erg cm^{-2} s^{-1} μm^{-1} and identified lines are indicated on the top of the spectrum.*

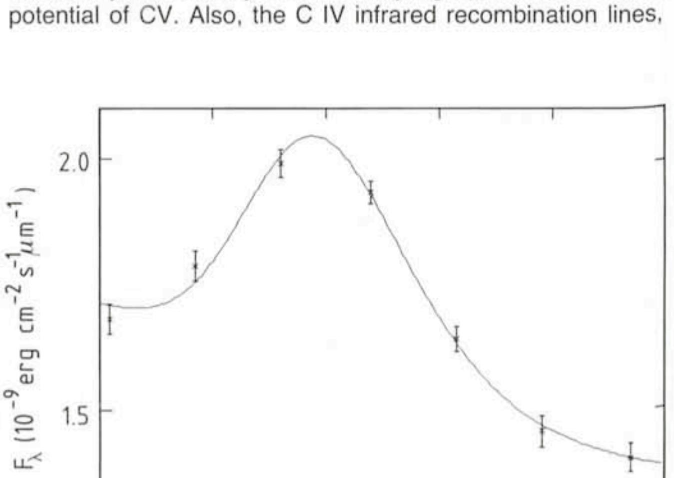

Fig. 2: *The 1.56 μm broad feature fitted with two Gaussian lines having the instrumental half-width of 0.017 μm. The best fit (minimum χ^2) parameters are λ_o = 1.557, I = 1.3 ($\pm$ 0.1)$\cdot 10^{-11}$ erg cm^{-2} s^{-1} and λ_o = 1.575, I = 3.6 ($\pm$ 1.1)$\cdot 10^{-12}$ erg cm^{-2} s^{-1} for the two lines.*

e.g., the 10-9, 2.429 μm, observed in other high excitation objects such as Wolf-Rayet stars (Aitken et al., 1982, *Monthly Notices of the Royal Astronomical Society,* **200,** 698) are not present in our spectrum of the nova. On the other hand, the weak feature marginally detected at 1.45 μm could be attributed to OVI, and a NV resonance line is present in the UV spectrum. Tentatively, therefore, we attribute the newly discovered 1.56 μm feature to an unresolved group of recombination lines dominated by He II, OV and NV. One consequence of this interpretation is that, combined with our upper limit on CIV, the required abundance ratio C/(N+O) is lower than solar, in line with current nova theories. It should be mentioned, however, that our spectrum at longer wavelengths clearly shows another broad emission feature at 3.5 μm which has been observed in other novae (e.g., Black and Gallagher, 1976, *Nature* **261,** 296) and has been attributed by Blades and Whittet (1980, *M.N.R.A.S.* **191,** 701) to fluorescent excitation of formaldehyde in dust grain mantles. It may therefore not prove possible to totally exclude a molecular origin for the 1.56 μm feature until higher resolution spectra can be obtained of future nova.

Photometric and Spectroscopic Mass Ratios of W UMa Stars

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Introduction

W UMa binary stars represent a typical case of astronomical objects for which theory and techniques of data reduction are much more developed and up to date than observations. While the analysis of photometric observations by means of synthetic light curve methods (Wilson and Devinney, 1971 *Astrophysical Journal,* **166,** 605) yields good photometric elements, the absence of reliable spectroscopic data makes the determination of the absolute elements of these systems and therefore of their evolutionary status problematic.

W UMa Stars

W UMa stars are the commonest type of binaries near the sun. The typical object of this class is a solar-type contact binary (luminosity class V) with a mass ratio $q = 0.6$, a period of 0.35 day and spectra from A7 to G5. While a first glance produces the idea of an "easy" type of objects (two stars more or less on the main sequence), a more detailed examination of these systems yields a lot of theoretical problems on their evolutionary status and on the physical processes involved in the mass and energy exchange between the two components. According to Binnendijk (1970, *Vistas in Astronomy* **12,** 217) W UMa's can be subdivided into A-type and W-type systems. The classification is performed according to the geometry of the primary eclipse: A-type systems have a transit, whilst W types have an occultation as primary eclipse. In other words, for A-type objects the eclipsed star, at primary minimum, is the larger and more massive companion, and the reversal is true for W-type ones. There are also other physical differences between these subclasses: A-type systems have an earlier spectral type, a higher luminosity, a larger mass, and a smaller mass ratio (Rucinski, 1973, *Acta Astronomica* **23,** 79; 1974, *Acta Astronomica* **24,** 119) than W UMa's of W type. Notwithstanding the numerous works regarding the age of W UMa's, the problem is still open. There are two hypotheses: the first favours the "youth" of W UMa's and their short intrinsic lifetimes (Van't Veer, 1979, *Astronomy and Astrophysics* **80,** 287; 1980, *Acta Astronomica* **30,** 381) whilst the second, because of the presence of some W UMa stars in old clusters (Rucinski, 1980, *Acta Astronomica* **30,** 373), supports high stellar ages.

Determination of mass ratio

Concerning the spectroscopic determination of the mass ratio of these systems there are some problems, mainly due to the shortness of periods and faintness of components: these facts prevent us from obtaining well distributed points on the radial velocity curves and hence reliable mass ratios. The mass ratio can, however, be determined also from the photometry (Wilson, 1978, *Astrophysical Journal* **224,** 885), using light curve synthesis models. However, the reliability of this type of determination is questionable, owing to the problem of the non-uniqueness of the solution. In other words there are well-behaving systems for which the solution is unique whilst other systems may have many local minima on the hypersurface of possible solutions in the space of the parameters, so it can happen that with a differential correction procedure, one obtains a solution in a local minimum and not in the absolute minimum of the hypersurface mentioned above, with obvious consequences on the reliability of the mass-ratio determination (Mancuso, S. Milano L., Russo G., Sollazzo C., 1979, *Astrophys. Sp. Science,* **66,** 475). Taking into account these conclusions on the reliability of the "photometric mass-ratios" we decided to begin a work of mass-ratio determination both by solving with the Wilson and Devinney method the observed light curves (Maceroni, Milano, Russo, Sollazzo, 1981, *Astronomy and Astrophysics Suppl.* **45,** 187) and by observing radial velocity curves.

Observations and Data Reduction

The aim of our observing programme was to get spectra of a sample of W UMa's, with known photoelectric light curves. During December 1981 we got 60 low-resolution spectra (74 Å/mm) for YY Eri, TY Pup and UZ Oct on IIa-O, nitrogen-baked emulsion with the RV Cassegrain spectrograph at the ESO 1.5 m telescope, to measure radial velocities and get reliable absolute elements, using both spectroscopic and photometric observations*. The spectra were digitized with the Perkin-Elmer PDS microdensitometer at Naples Observatory. The

* In the same observing run, a number of spectra were obtained using the three-stage image tube available at the 1.5 m; unfortunately these spectra turned out to be too noisy for our purpose.

reduction of the digitized spectra was performed on the PDP11/34 computer at the same Institute. While the wavelength and intensity calibrations were easily performed on all spectra, the determination of the radial velocities proved to be very tricky because of the low dispersion and the high rotational broadening of the spectral lines. Therefore an 'ad hoc' data processing code is under development, and hence the analysis of the spectra has not yet been completed.

The result of this work will be published, when completed, in the *Astronomy and Astrophysics Supplements.*

List of Preprints Published at ESO Scientific Group

June–August 1983

253. P. A. Shaver and J. G. Robertson: Absorption-line Studies of QSO Pairs. *Memorie della Società Astronomica Italiana.* June 1983.
254. G. Contopoulos: Infinite Bifurcations, Gaps and Bubbles in Hamiltonian Systems. *Physica D.* June 1983.
255. O.-G. Richter and W. K. Huchtmeier: Is there a Unique Relation between Absolute (Blue) Luminosity and Total 21 cm Linewidth of Disk Galaxies? *Astronomy and Astrophysics.* June 1983.
256. E. A. Valentijn and W. Bijleveld: The Trivariate (Radio, Optical, X-ray) Luminosity Function of cD Galaxies II: The Fuelling of Radio Sources. *Astronomy and Astrophysics.* June 1983.
257. C. Kotanyi, J. H. van Gorkom and R. D. Ekers: Einstein Observations of NGC 4438: Dynamical Ablation of Gas in the Virgo Cluster. *Astrophysical Journal.* June 1983.
258. J. R. Dickel and S. D'Odorico: Radio Emission from Supernova Remnants in M31 at a Wavelength of 6 cm. *Monthly Notices of the Royal Astronomical Society.* June 1983.
259. P. Bouchet and P. S. Thé: Notes on the Open Cluster NGC 1252 with the Variable Carbon Star TW Hor as Probable Member. *Publications of the Astronomical Society of the Pacific.* June 1983.
260. C. Kotanyi, E. Hummel and J. van Gorkom: Are there Jets in Spiral Galaxies? "Astrophysical Jets", workshop held in Torino, Italy, 7–9 Oct. 1982. June 1983.
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262. G. Contopoulos: Bifurcations, Gaps and Stochasticity in Barred Galaxies. *Astrophysical* Journal. July 1983.
263. J. Melnick, R. Terlevich and P. P. Eggleton: Studies of Violent Star Formation in Extragalactic Systems. I. Population Synthesis Model for the Ionizing Clusters of Giant H II Regions and H II Galaxies. *Monthly Notices of the Royal Astronomical Society.* July 1983.
264. R. Terlevich and J. Melnick: Studies of Violent Star Formation in Extragalactic Systems. II. The Relation Between the Initial Mass Function and Chemical Composition. *Monthly Notices of the Royal Astronomical Society.* July 1983.
265. P. Véron: Quasar Surveys and Cosmic Evolution. 24th Liège International Astrophysical Symposium "Quasars and Gravitational Lenses", June 21–24, 1983. July 1983.
266. J. Koornneef: Near-Infrared Photometry Paper II: Intrinsic Colours and the Absolute Calibration from One to Five Micron. *Astronomy and Astrophysics.* July 1983.
267. P. L. Schechter, M.-H. Ulrich and A. Boksenberg: NGC 4650A: The Rotation of the Diffuse Stellar Component. *Astrophysical Journal.* July 1983.
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Fiber Optics at ESO

Part 2: Fiber Optics Multiple Object Spectroscopy at the 3.6 m Telescope

D. Enard, G. Lund and M. Tarenghi, ESO

During a 6-day test period late in November 1982, a prototype optical fiber device (nicknamed "Fiber Optopus") was tested at the 3.6 m telescope Cassegrain focus. The principle of this device, described in more detail in the following paragraphs, is such that the light from up to 50 randomly separated points on the sky (within the Cassegrain focus field of view) can be simultaneously guided via separate flexible optical fibers to the entrance slit of the B&C spectrograph. By making use of a two-dimensional detector such as a CCD the individual spectra, corresponding to each sampled point on the field, can be recorded simultaneously. When fully operational, the Fiber Optopus should enable a very strong reduction in telescope time to be achieved in observing programmes involving low resolution spectral mapping of extended fields. This feature will be of great interest to astronomers wishing to observe clusters of faint objects requiring long integration periods.

Technical Description

The prototype system, represented schematically in fig. 1, depends on the following essential components:

- the Fiber Optopus containing 50 free optical fibers, appropriately terminated in magnetic connectors,
- a starplate for the particular field to be viewed,
- three coherent fiber bundles and a TV camera for guiding,
- the Boller and Chivens spectrograph,
- a two-dimensional detector (CCD).

In addition, auxiliary calibration lamps, power supplies and a handset for the remote control of these functions and of the TV camera are provided. A description of the instrumental components developed specially for multiple object spectroscopy is given below.

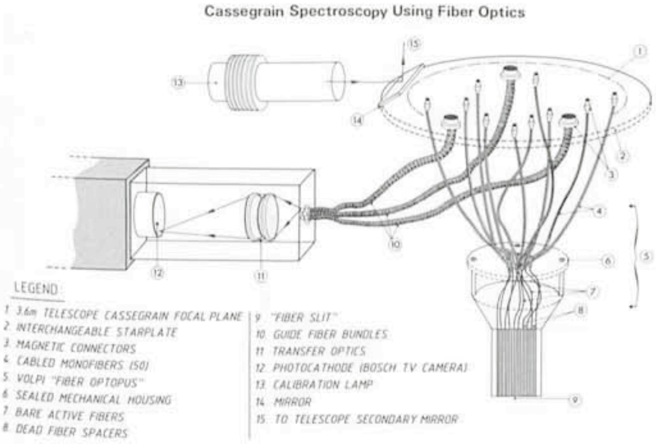

Fig. 1: *Schematic representation of the multi-fiber spectroscopic feed: Here, only 10 of the 50 individual fibers are shown. Light gathered from individual points, designated by precisely located holes in the starplate, is delivered to the Boller and Chivens spectrograph via the mechanically aligned fiber outputs (9). Guiding is achieved by use of coherent fiber bundles (10) and a TV camera.*

Fiber Optopus

The name of this device was chosen because of its optical fiber composition and its octopus-like appearance, as can be appreciated from the photographic illustration in fig. 2. The Optopus, which is the heart of the multiple object spectroscopic system, consists essentially of 50 independent fibers of 200 μm core diameter (about 1.5 arcsec on the sky). Each fiber is protected by an external numbered cable, terminated at one end by a magnetic male connector, and assembled at its other end into a common solid housing.

Inside the housing, the protective cables are removed and the protruding bare fibers are aligned in numerical order in a straight row (interspaced with single dead fibers for better spectral separation at the detector). The ensemble of bare fiber ends (clamped and epoxied into the housing) is optically polished, and thus replaces the conventional Boller and Chivens entrance slit by a line of consecutive circular 200 μ diameter output spots, each of which produces individual spectra on the spectrograph detector.

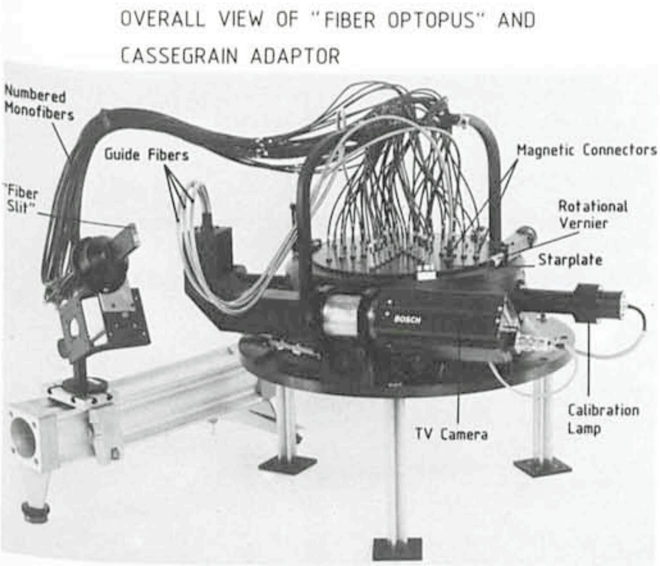

Fig. 2: *Photographic view of the Optopus and associated hardware, before installation on La Silla. The metallic housing attached to the TV camera contains transfer optics for the guidestar images.*

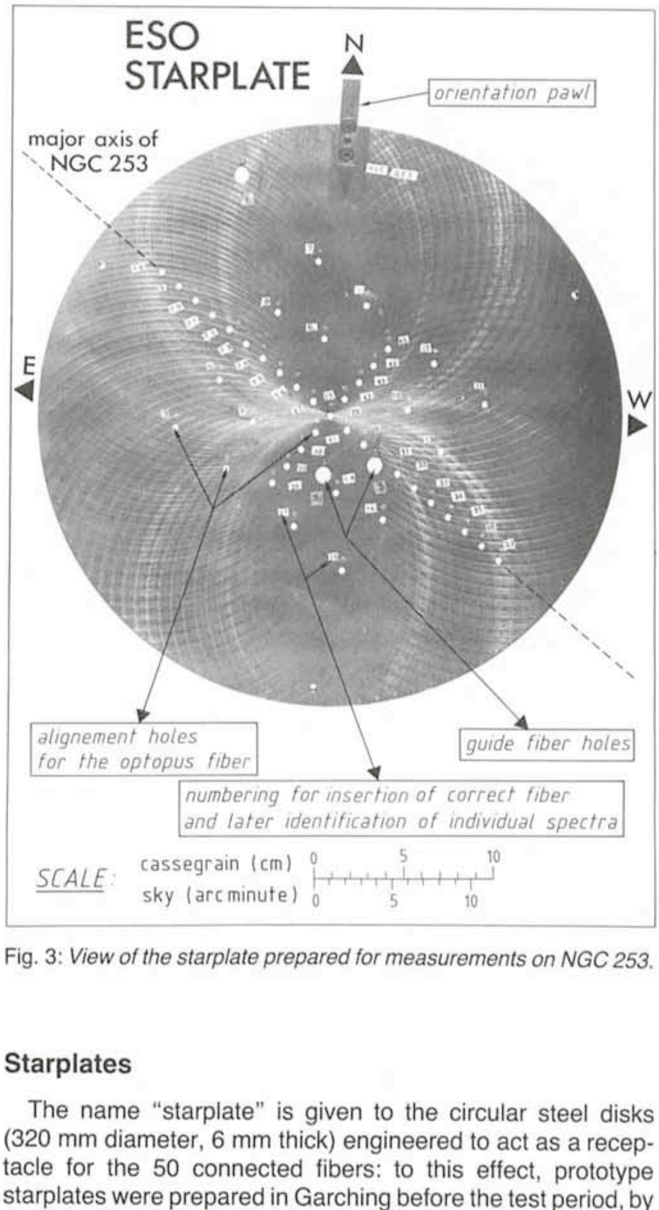

Fig. 3: *View of the starplate prepared for measurements on NGC 253.*

Starplates

The name "starplate" is given to the circular steel disks (320 mm diameter, 6 mm thick) engineered to act as a receptacle for the 50 connected fibers: to this effect, prototype starplates were prepared in Garching before the test period, by drilling accurate connector holes according to the scale of the 3.6 m at the Cassegrain focus.

In order to simplify the production of starplates, which are in principle dispensible items, the fiber connection was achieved by means of simple cylindrical holes reamed to an accurately known diameter. Due to the rather cumbersome design of the magnetic connectors (10 mm diameter) a minimum separation between holes of 10.5 mm was imposed, corresponding to a lower limit of 85 arcsecs for the proximity of objects to be observed with the same starplate.

The guidestar cables, described below, were connected to the starplate via 8 mm diameter cylindrical holes. As can be seen in fig. 3, these holes were also associated with small orientation pins which ensured congruent movements of the observed guidestars when viewed on the TV monitor.

Although it is known that there is a Cassegrain field curvature corresponding to roughly 3 mm between centre and edge of the field, no correction for the resulting defocusing was attempted. This will however be essential in our definitive system.

Guiding System

Since with the use of the multiple fiber adapter the conventional spectrograph slit is removed and replaced by the Optopus output slit, guiding by means of the normal slit viewing system is impossible. Furthermore, since the field is sampled by many fibers at scattered positions, it is very important to establish the correct rotational positioning of the starplate in order to ensure correct alignment of all fibers with their respective objects. The solution adopted for Optopus spectroscopy consists in using coherent fiber bundles which allow any randomly positioned star to be viewed at the fixed bundle outputs via a TV camera. Two sufficiently bright guide stars should be adequate for establishing the correct (α, δ) and rotational alignment of the starplate. The image guiding bundles used for this purpose are each 1 m long and consist of 4 mm diameter (i.e. 30 arcsecs) tightly packed, coherently ordered bundles of 50 μ fibers. An image focused onto such a bundle can be viewed at the other end in the form of a mosaic of about 5,000 points. Under good seeing conditions (~ 1.5 arcsecs) a guidestar would thus cover about 14 mosaic points, allowing good visual determination of its output image position (coverage of only 3 or 4 fibers would give rise to jittery movements at the output). A crosshair reference system was designed to visualize the output image position corresponding to the exact geometrical centre of the cylindrical connector at the input end. This was achieved by photographically reducing a crosshair to a line thickness of about 40 μm. By illuminating the centre of the bundle input end with a small spot the crosshair was precisely located (using a microscope) and glued in the laboratory to the corresponding output image centre. Laboratory measurements showed the resulting crosshair positional accuracy to be better than 50 μm (~ 0.4 arcsec) for all three guide fibers.

By means of two transfer doublets the bundle output faces were imaged onto the photocathode of the TV camera, and a focus adjustment was provided by a sliding movement for the lens barrel. At the beginning of the experimental run, rotational inaccuracies of the starplate (as seen by the positions of the guide stars relative to their respective crosshairs) were initially corrected via the vernier movement on the fiber adapter (fig. 2), allowing small rotations of the starplate relative to the optical axis of the telescope. The angular reference pawl, fixed in exactly the same way to each starplate (fig. 3), was designed to ensure that no further vernier adjustments were necessary with starplates subsequent to the first. Thereafter, correct guiding was ensured by visually maintaining the brightest guide star centred on its crosshair.

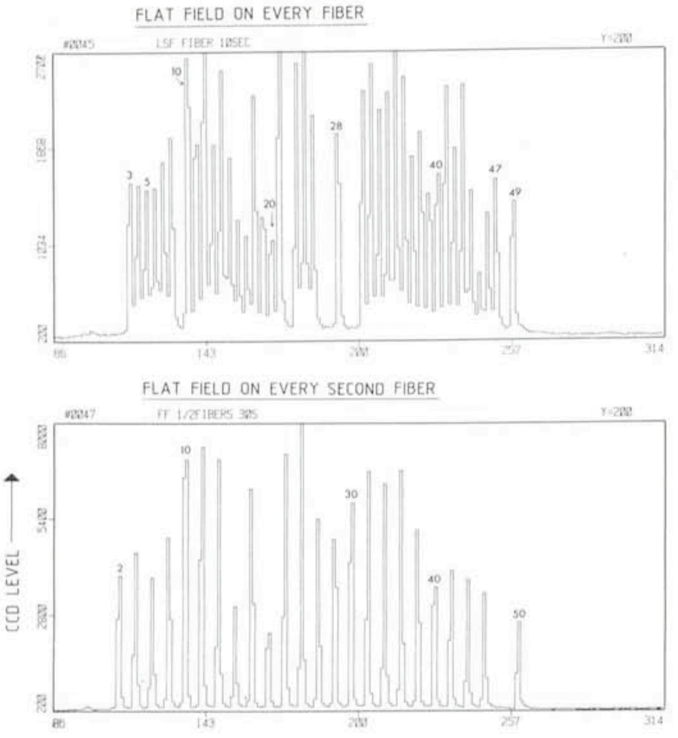

Fig. 4: *Cross-sectional views of one CCD line showing varying fiber output intensities at a given wavelength. When every second fiber is removed the crosstalk effects apparent in the upper figure disappear. The fibers apparently missing from these figures were either unplugged or broken (in the case of nos. 1 and 48).*

Hardware Tests and System Performance

Initial setting up of the fiber system involved firstly the task of shifting the Boller & Chivens spectrograph to a specially prepared structure within the Cassegrain cage, and replacing it by the Optopus adapter which was bolted onto the Cassegrain flange. Thereafter, initial alignment requirements included focusing the spectrograph collimator, rotating the detector and Schmidt camera to give spectra aligned along the CCD pixel rows (small angular offsets can easily be detected in the form of Moiré fringe patterns on the CCD image), focusing of the telescope by the standard Foucault test and thereafter via a guide bundle near to the optical axis, and checking of all electrical functions proper to the Optopus system. No major difficulty was encountered during these operations. The routine operation of starplate changeovers was sometimes hindered by overtight connectors, although the sorting of fibers in order to maintain the correct numerical correspondence between fiber and sky positions was generally the most time-consuming operation. A complete starplate changeover generally took 15 to 20 minutes.

(i) Guiding

The guiding system performed very well since visual balancing of the guide star image in the 4 quadrants created by the crosshair proved to be quite a simple task. In cases when the guidestar lay close to the edge of the usable field, the image was somewhat dilated (due to field curvature defocusing) but guiding was nevertheless possible. In practice it was found that stars fainter than magnitude 12 were not satisfactory for guiding purposes with the present TV camera. This weakness was attributable to slow transfer optics, to losses in the guide bundle fibers, and to poor sensitivity of the camera. The future generation Optopus system will be improved in this respect by using a more sensitive (perhaps a CCD type) TV camera and improved transfer optics.

(ii) Spectral crosstalk

One considerable difficulty encountered was related to the "tail" of incompletely transferred charge left behind by a relatively strong signal during readout. This phenomenon gives rise to considerable crosstalk between spectra from adjacent fibers, as can be seen in fig. 4. Removal of every second fiber, however, virtually eliminates the crosstalk problem. The strong differences in effective transmission through different fibers, noticeable in this figure, are thought to be due mainly to focal ratio degradation which occurs within the fibers. The fibers used are particularly prone to this effect (often associated with "microbending"), which tends to spread the output beam well beyond the focal ratio of the input, if care is not taken to minimize mechanical pressure on the fibers. The transmission losses due to absorption were measured in the laboratory and found to be less then 20 % for almost all fibers in the wavelength range from 4500 Å to 9000 Å.

Astronomical Applications

During the test run a number of spectral images of potential astronomical interest were acquired in order to assess the system's capacity for investigating extended nebulae, galaxies and star or galaxy clusters:

(1) A two-hour exposure of the galaxy NGC 253 was recorded using sampling points along its major and minor axes in addition to a few points on the sky (see fig. 3). It should be possible to study the behaviour of the galaxy's rotation curve over a field of 20 minutes, when these data are reduced.

(2) The coordinates of Hα emission line regions obtained from a triplet plate of the 11th magnitude spiral galaxy NGC 300 were used to produce a starplate for studying more closely the HII regions in this galaxy and their associated spectra.

(3) In order to simplify the observation of extended nebulous structures, a starplate was prepared with a uniform grid of 7 $\times$ 7 points spaced at 107 arcsec intervals, thus covering a field of roughly 11 $\times$ 11 arcminutes. As an example, we show here in fig. 5 a negative reproduction of part of the Orion nebula on which an overlay of the fiber grid, as it was used in the observation, has been printed. The central guide fiber was aligned with θ_2 Orionis (the brightest of the Trapezium group), and correct rotational alignment of the plate was verified by moving the telescope 428 arcsecs south – and verifying that θ_2 was centred on the "upper" guide fiber. A second verification could be similarly made by moving the telescope 428 arcsecs west of its original position, and checking the image on the third guide fiber. The white numbers indicated on the overlay can be used to identify the fiber numbers which were plugged in sequentially back and forth across the grid. This grid was also used for observations of the Tarantula and Eta Carinae nebulae.

The complete CCD image obtained from Orion is shown in fig. 6, where the emission lines of H_γ, H_β, H_γ, [OIII], [OI], HeI, [NII], [SII] and [AIII] have been indicated. An enlarged portion of this spectrum is shown in fig. 7, revealing more detailed structure in the [NII] and [SII] emission lines. Close inspection of these figures reveals that the spectra are rotated slightly

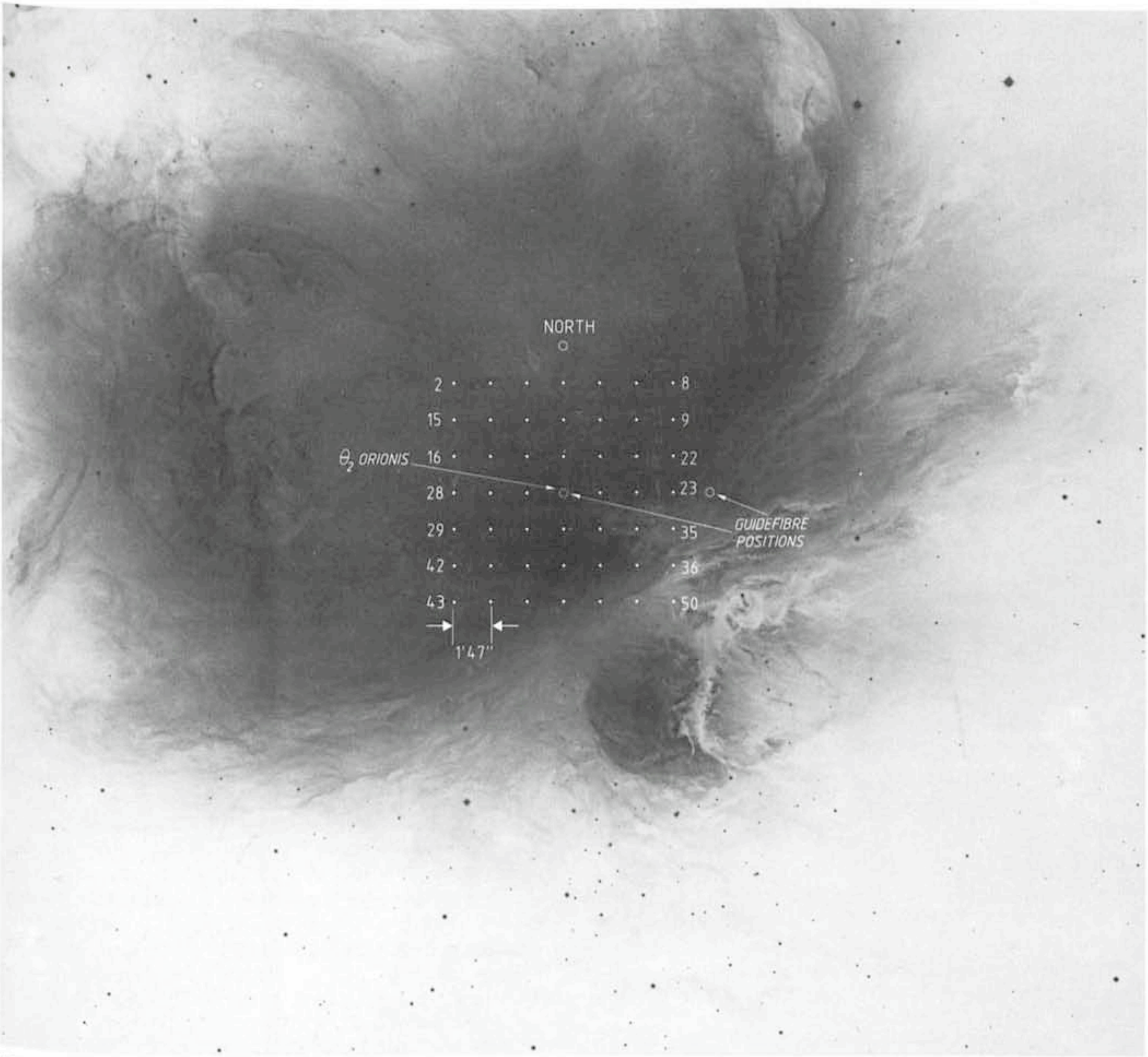

Fig. 5: *Reversed image of part of the Orion nebula, with a white overlay indicating the locations of a 48 fiber grid and of 3 guide fibers. The central guide fiber was centred on θ_2 Orionis (the brightest of the Trapezium stars). The scale here is that equivalent to a 3.6 m prime focus plate (18.9 arcsec/mm).*

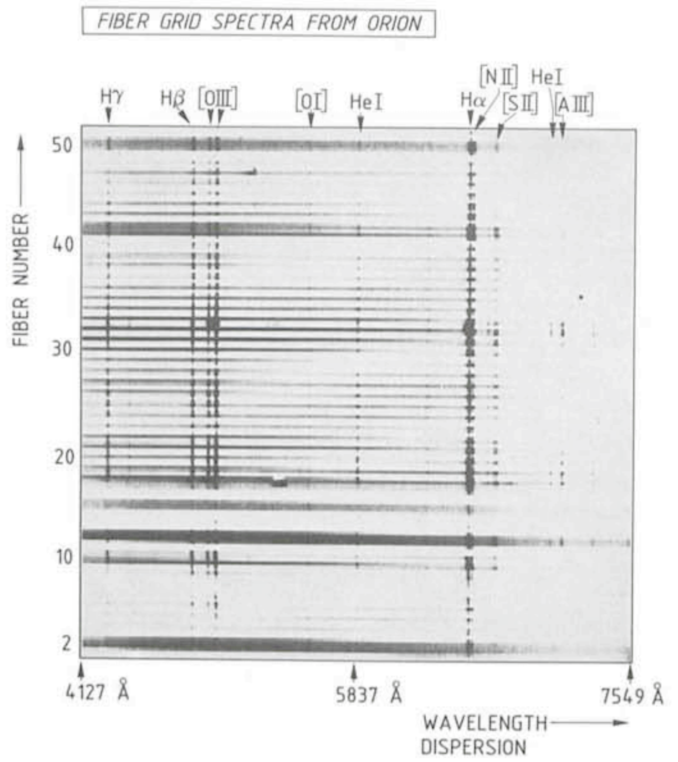

Fig. 6: *Multifiber CCD spectra taken from Orion with the grid starplate illustrated in fig. 5 using a low dispersion grating (171 Å/mm). Dispersion is shown horizontally, with the individual lines corresponding to fibers 2, 3 . . . (48) . . . 50. One can easily discern the H_α, H_β, [O III], He I, H_α and [S II] emission lines. [O I], [N II], and [A III] can also be perceived.*

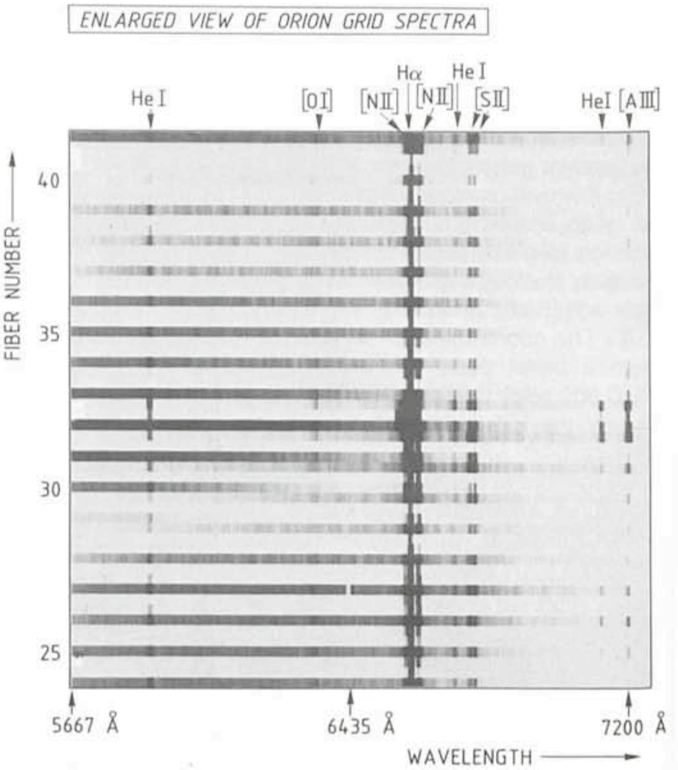

Fig. 7: *Enlarged view of part of the CCD spectrum shown in fig. 6, clearly showing the He I, [N II], H_α and [S II] emission lines present in some or all of the fibers numbered 24 to 41.*

clockwise with respect to the CCD lines. This inconvenience renders the data reduction difficult if extreme care is not taken with correcting for the variable distribution of energy over two or more pixels, for a given fiber at different wavelengths. The crosstalk problem alluded to in fig. 4 is an additional source of difficulties. The CCD chip and all spectrograph optics must be absolutely stable and immune to flexure between the time of spectral and flat-field exposures, if the flat-field correction is not to introduce inappropriate noise to the pixels of interest.

For future studies of galaxy dynamics it will in many cases be convenient to use a standard starplate consisting of a guide fiber located in the centre, together with 50 sampling fibers positioned along either of two orthogonal axes. Having centred the galaxy nucleus on the guide fiber it should be a simple task to rotate the plate in such a way as to align its sampling axes with the major and minor axes of the galaxy. Fairly precise knowledge of the individual fiber positions can be determined a priori, by specifying a plate rotation through a known angle relative to a fixed reference.

Conclusions

Although the Optopus system was developed in a rather short time (6 months) the test run has put into evidence the great potential of multiple object spectroscopy using fiber optics.

Many problems became apparent during the tests, and it is hoped that the 2nd generation device now being developed at ESO will be free of these difficulties, enabling it to exhibit optimal performance in all respects. In particular, the following improvements or modifications will be carried out:

- use of more suitably adapted fibers (in terms of desensitivity to microbending),
- use of connector microlenses to adapt the fiber input beam to f/3,
- design of miniconnectors around 3 mm in diameter (~ 21 arcsecs minimal separation between adjacent fibers), with a more secure fixation principle,
- correction for field curvature in the starplate,
- replacement of the present TV camera by a more sensitive type (perhaps with a CCD detector) to allow guiding on stars down to magnitude 16,
- arrangement of the output fiber slit so as to cover the entire CCD width by the 50 output fibers, thus ensuring adequate empty spacing between adjacent spectra (~ 4 pixels).

Proper functioning of the entire multiple fiber spectroscopy system will also implicate the use of computer software for the following purposes:

- Direct production of magnetic tape programmes for the starplate drilling machine: the drilling coordinates should be determined according to user-interactive measurements of Schmidt plates at ESO, or from accurate data supplied from elsewhere. The drilling instructions will include depth control for field curvature correction.
- On-line data reduction of the raw spectra using software similar to that designed for CASPEC, with the additional capacity for producing contour maps of extended fields in terms of wavelength, temperature, radial velocity, etc.

The new system hardware will be ready for tests at the beginning of the observing period starting in April 1984, and it is hoped that fiber OPTOPUS will be available to visiting astronomers for the following observing period.

Acknowledgements

Of the numerous ESO staff members who were of assistance in the development of the OPTOPUS prototype, we would like to extend our particular thanks to S. Balon, B. Buzzoni, S. Cristiani, P. Giordano, G. Huster and J.L. Lizon.

Kinematics and Radio Structure in the Seyfert Galaxy NGC 5728

J. H. van Gorkom, NRAO, Socorro, New Mexico
C. G. Kotanyi, M. Tarenghi, M.-P. Véron-Cetty and P. Véron, ESO

Introduction

The centre of most Seyfert galaxies contains a radio source with sizes ranging from a few hundred to a few thousand parsecs. Optical forbidden lines are generated in regions of similar sizes. Discrete optical line-emitting clouds have also been observed in these regions in some of the nearby Seyfert galaxies.

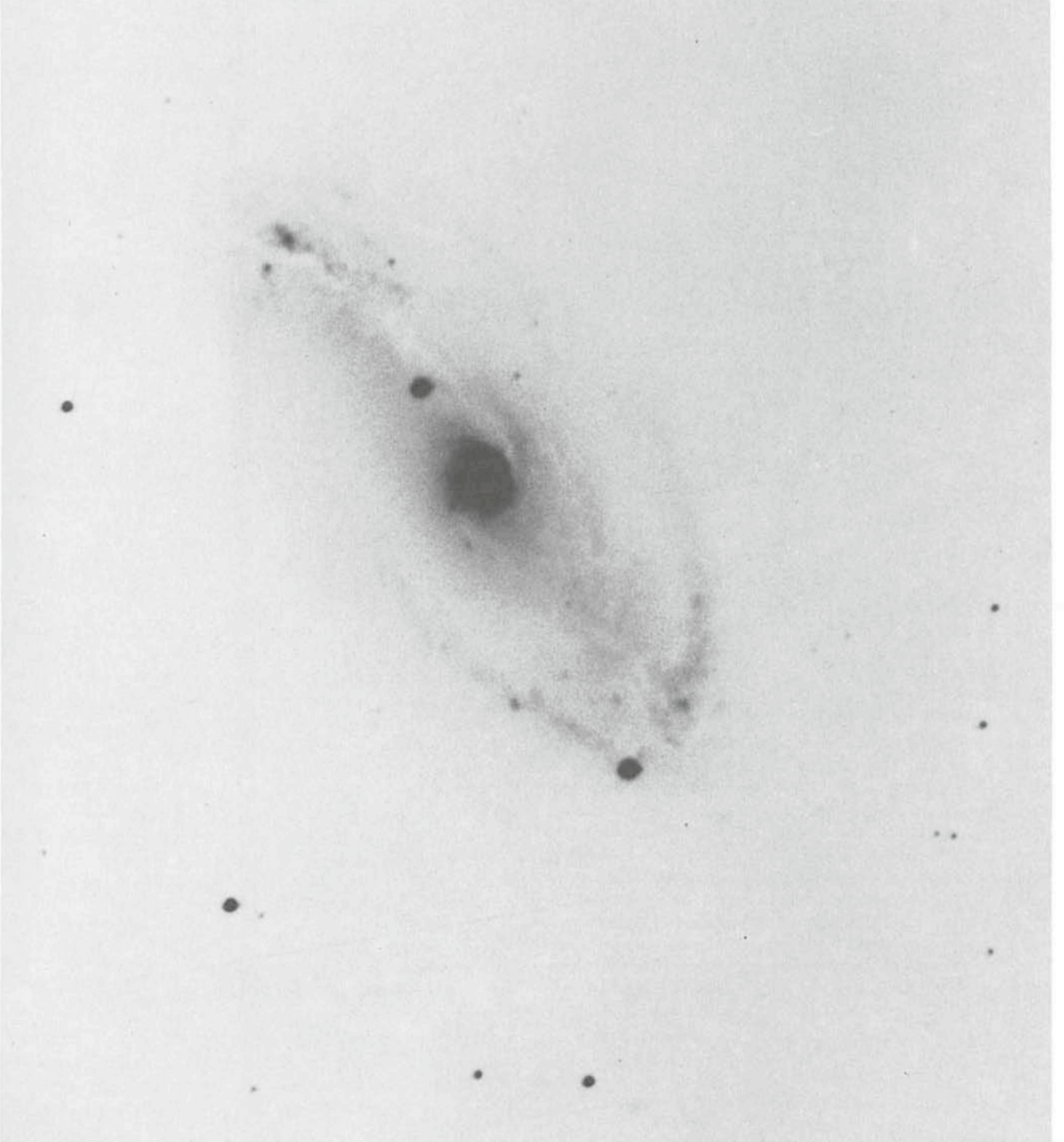

Fig. 1: *Direct photograph of the galaxy NGC 5728 obtained at the prime focus of the 3.6 m CFH telescope at Hawaii, on May 17, 1982 through a GG385 filter on baked IIIa-J emulsion. 45 min. exposure. North is at the top, east to the left.*

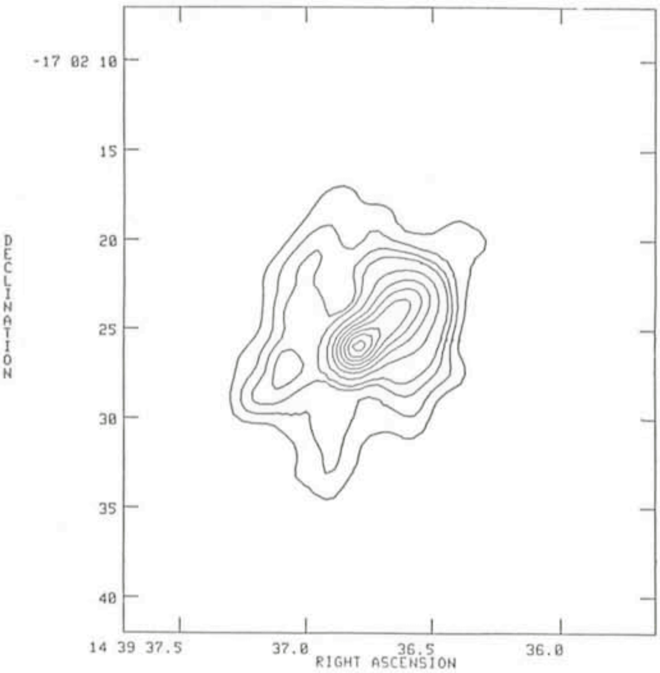

Fig. 2: *Radio map of NGC 5728 at 1465 MHz obtained with the VLA. The resolution is 2 arcsec.*

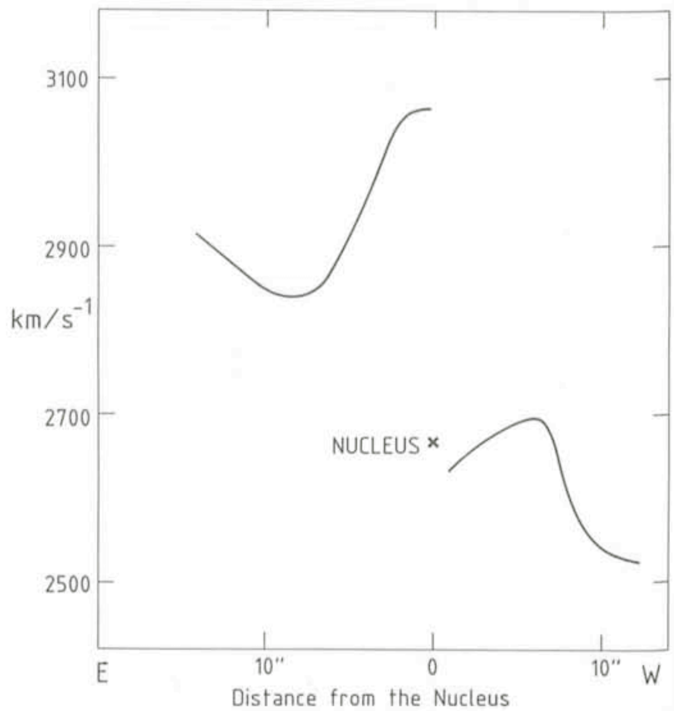

Fig. 3: *Velocity curve of the gas in the nuclear region of NGC 5728 measured along the slit on a spectrum taken in P.A. 296°. The emission lines measured were [OIII] λλ4959, 5007 and Hβ.*

The central radio sources have usually a complex structure. Often the emission is diffuse, with a peak coincident with the optical continuum nucleus. In a few cases linear, radial structures have been seen suggestive of "jets" (1). The relationship between the radio-emitting region and the ionized gas is not well understood. In NGC 5728 we have discovered a rather good correspondence between the structure of these two emission regions.

A photograph of NGC 5728 is shown in fig. 1. In previous observations (2) this SBb galaxy was found to be a Seyfert 2 with strong emission lines (a first mention of its Seyfert nature appears however in (3)). The emission-line region has a size of about 10″. A radio source of flux density 51 mJy was known to exist in this galaxy from 2.7 MHz observations (4), and we have mapped it at high resolution.

Radio Observations

The data were taken using the Very Large Array* near Socorro, New Mexico. We have observed the galaxy at the frequencies of 1.4 and 5 GHz, in the summer of 1982. The observations have angular resolutions of 1″ and the r.m.s. noises are respectively 0.2 and 0.1 mJy/beam.

The maps show a diffuse emission region with a size of about 10″ coextensive with the optical emission-line region. This component is bounded to the west by a brighter rim, which coincides with a ring of emission in the emission-line region (see photograph in (2)). A compact nucleus (size < 1″) is present with a flux density of 3 mJy at 1.4 GHz. A radial component of emission is also present, extending about 5″ from the nucleus in position angle –45°. Fig. 2 shows the map at 1.4 GHz, smoothed to a 2 parsec resolution.

The flux densities at 1.4 GHz and 5 GHz are respectively 46 and 30 mJy. A map of the spectral index suggests that the emission is non-thermal.

Spectroscopic Observations

On 19 May 1983 we obtained a number of long slit spectra of the central part of NGC 5728 in three position angles (210, 270 and 296°) with an EMI image tube attached to a Boller and Chivens spectrograph at the Cassegrain focus of the ESO 3.6 m telescope. The slit width was 1.5 arcsec, the dispersion 114 Å/mm corresponding to a resolution of 4.3 Å (FWHM); the plate scale was 38″.5 mm^{-1}; the seeing about 2.5 arcsec.

The best spectra are the three corresponding to P. A. = 296° with exposure time of 1, 3 and 10 minutes respectively. On the most exposed of these spectra, we have measured the redshift of the visible absorption lines (NaD λ5892, Ca+Fe λ5269, Mg I λ5175, H9 λ3836 and H10 λ3799; Ca I λ3934 (K line) has not been measured as its observed wavelength corresponds accidentally to the atmospheric Ca I λ3968 (H line)); the resulting heliocentric radial velocity is $V = 2{,}676 \pm 30$ km s^{-1}.** We have measured the emission lines Hβ and [OIII] λλ4959, 5007 on each of these three spectra; the results are plotted in fig. 3. They show a receding component to the east of the nucleus, with a redshift of 200 to 350 km/s relative to the nucleus. West of the nucleus, the material is almost at rest. This is in agreement with Rubin's result. Beyond 10″ from the nucleus the lines are very faint; the data indicate that the gas may share the rotation motion of the galaxy.

A bright emission-line nebulosity is present in P.A. –45°, coinciding with the peak in the radio radial component.

The non-circular motions could be interpreted as a bipolar flow associated with the centre of the galaxy. The absence of an approaching component on the east side and of a receding component on the west seems to exclude the possibility of a spherically expanding (or contracting) shell. The motions

* The National Radio Astronomy Observatory is operated by Associated Universities Inc. under contract with the NSF.

** Rubin (5) adopted 2,800 km/s.

therefore seem to be associated with the radial features near P.A. –45°, showing at both optical and radio wavelengths. We would conjecture that the flow occurs in a rather wide cone, rather than in a narrow, collimated "jet", since the optical radial features appear to be fairly broad transversally.

Rubin (5) attributed the non-circular motions in NGC 5728 to a non-axisymmetric perturbing potential due to the bar of the galaxy. However she had not recognized the Seyfert nature of the galaxy. We rather believe that these motions are due to the nuclear activity.

Spectroscopic observations at more slit position angles are clearly needed to better determine the true motions of the gas in the nuclear region of this galaxy.

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ALGUNOS RESUMENES

Otto Heckmann

1901–1983

Otto Heckmann, ex-Director General del Observatorio Europeo Austral (1962–1969), ex-Presidente de la Unión Astronómica Internacional (1967–1970), y de la Sociedad Astronómica Alemana (1952–1957), ex-Profesor de Astronomía y ex-Director del Observatorio de Hamburgo (1941–1962), falleció el 13 de mayo de 1983.

El Observatorio Europeo Austral tiene especiales razones de agradecimiento para Otto Heckmann cuyo impulso creativo fue la principal contribución para llegar finalmente a la realización de esta organización europea.

Nacido el 23 de junio de 1901 en Opladen desarrolló ya muy temprano su interés por problemas astronómicos. F. Küstner de la Universidad de Bonn lo introdujo a la astronomía clásica de posiciones y muy probablemente fue él quien formó su estilo científico. Después de haberse doctorado en Bonn, muy pronto, sin embargo, aceptó una invitación de H. Kienle a Göttingen, donde se enteró de modernos problemas de astrofísica.

Siendo un excelente observador, muy pronto pudo mejorar la precisión de la fotometría fotográfica a un nivel hasta ahora jamás igualado. Fueron famosas sus investigaciones de los diagramas de color-magnitud en cúmulos abiertos, realizadas en conjunto con H. Haffner.

Fascinado por el descubrimiento de E. Hubble en 1929 respecto a la relación que existe entre el desplazamiento hacia el rojo y la distancia de nebulosas extragalácticas, resumió investigaciones anteriores sobre cosmología que finalmente dieron resultado a la publicación de su libro "Teorías de la Cosmología" que apareció más tarde en Hamburgo en 1942.

Otto Heckmann siempre mantuvo un buen contacto con Walter Baade, y éste dando conferencias en el Observatorio de Leiden en 1953 le acentuaba a los astrónomos europeos la gran importancia de un observatorio europeo común "localizado en el hemisferio austral, equipado con poderosos instrumentos, con la meta de fomentar y organizar la colaboración en la astronomía".

Durante una conferencia fundamental con W. Baade en primavera de aquel año un número de distinguidos astrónomos europeos, entre ellos A. Danjon de Francia, P. Bourgeois de Bélgica, J. H. Oort de los Países Bajos, Sir Harald Spencer-Jones de Gran Bretaña, B. Lindblad de Suecia, O. Heckmann de la República Federal de Alemania, decidieron llevar a cabo tal proyecto. En los años subsiguientes fue, sin embargo, siempre Otto Heckmann quien dio los impulsos, dando esperanza y fé cuando el desaliento y la depresión amenazaban el éxito del plan.

Fue nuevamente Otto Heckmann quien en el año 1962, después de haber sido nombrado Director General, y hasta su jubilación en 1969, cargó con la inmensa tarea de levantar la sede de la ESO y el Observatorio La Silla en Chile, poniéndolos finalmente en funcionamiento.

Con Otto Heckmann ha desaparecido un destacado astrónomo, honrado en su reconocimiento con los títulos de Dr. h. c. de la Universidad de Aix-Marseille en 1966, Dr. h.c. de la Universidad de La Plata en 1968, y Hon D.Sc. de la Universidad de Sussex en 1970, siendo miembro honorario de numerosas academias científicas tanto en Europa como en América, y habiendo recibido muchas medallas de oro de las cuales tan solo citamos como ejemplo la Medalla Bruce de la Sociedad Astronómica del Pacífico. *A. Behr*

Fotometría de estrellas variables a largo plazo en La Silla

Muchos astrónomos visitantes de ESO están involucrados en el estudio a largo plazo de la variabilidad de las estrellas. Sin embargo, los relativamente cortos períodos de observación y los largos intervalos entre cada visita de los observadores afectan la homogeneidad de los resultados.

Una posible solución hacia un más próspero estudio a largo plazo de las estrellas variables es la selección de un restringido número de objetos interesantes de diferente tipo y de observar éstos en una forma casi continua a través de los próximos períodos de observación.

Tal programa fue iniciado por una docena de observadores pertenecientes a varios institutos europeos a comienzos de 1982. El coordinador central del grupo es el Dr. Chr. Sterken de Bélgica.

Este programa prevé la medición fotométrica de alrededor de 120 estrellas: aproximadamente un 50 % de ellas deben ser observadas con una frecuencia de una medición por noche a través del período de observacion completo. La frecuencia de observación de las demás estrellas varía desde una medición dia por medio hasta una a dos mediciones por mes.

Desde octubre de 1982 ya han sido adjudicados 7 períodos de observación en los telescopios de 50 cm de ESO y 61 cm de Bochum durante un lapso usual de tres a cuatro semanas cada uno.

Luego del primer año de funcionamiento de este procedimiento se han obtenido ya algunos resultados interesantes:

ESO, the European Southern Observatory, was created in 1962 to . . . establish and operate an astronomical observatory in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organizing collaboration in astronomy . . . It is supported by eight countries: Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands, Sweden and Switzerland. It operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where twelve 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 120 local staff members in Santiago and on La Silla. In addition, there are a number of fellows and scientific associates.

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p. ej., se ha logrado perfeccionar el período de varias estrellas, y en otras se han encontrado importantes variaciones de una noche a la otra. Sin duda, las dos culminaciones han sido el descubrimiento de una erupción en una de las estrellas, y aquel de la naturaleza de estrella doble de una luminosa supergigante en la Gran Nube Magallánica.

Además de los resultados científicos, el programa ofrece también otros aspectos atractivos. Estímula la colaboración internacional, y jóvenes observadores europeos quienes aun no han establecido su propio campo de investigación pueden unirse al grupo. También existe una buena colaboración con el Dr. Maza de la Universidad de Chile respecto a informaciones sobre eventos, tales como novae galacticas brillantes.

Actualmente el grupo consta de 22 participantes y se espera que más personas se unan al proyecto.

Observaciones del cometa IRAS-Araki-Alcock desde La Silla

Como ya mencionado en la última edición del "Mensajero", hace algunos meses un cometa muy excitante cruzó la cercanía de la tierra. Inicialmente descubierto por el satélite infrarojo IRAS y luego por dos aficionados, Araki (Japón) y Alcock (Reino Unido), este cometa se acercó a la tierra hasta una distancia de sólo casi 4.5 millones de kilómetros el dia 12 de mayo de 1983.

Este evento proporcionó una oportunidad única para estudiar un cometa en una muy alta resolución espacial. Esto es de especial interés ya que la mayoría de la información existente sobre la naturaleza y el origen de cometas reside en la región central – núcleo y su inmediata cercanía – generalmente demasiado pequeña para ser observada desde la tierra. En el caso del cometa IRAS fue posible obtener una resolución espacial de aproximadamente 10–20 km en el momento de su mayor acercamiento.

El cometa IRAS fue observado con tres instrumentos desde La Silla: con el telescopio de 3,6 m se obtuvieron espectros IDS y con el telescopio de 1,52 m espectros de tubo de imagen, y con el telescopio danés de 1.54 m se registraron imágenes CCD. Estos datos están siendo reducidos actualmente. Posiblemente podrán confirmar otras observaciones, tanto visuales como de radar, que sugieren la existencia de un "capullo" alrededor del núcleo del cometa.

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