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ITALY, Member of ESO

On May 24, 1982, the Italian Ambassador in Paris deposited the instrument of accession with the Ministry of Foreign Affairs of the French Republic, as foreseen by Art. 13 of the ESO Convention. With this act Italy has become a member of ESO.

Perhaps it is of some interest to summarize the main historical steps which in the end led to this very positive conclusion. Apparently the main reason why Italy did not participate in the foundation of ESO is because Italian astronomers in the early '60s were essentially divided between the desire to participate in the founding of ESO and the equally strong desire to have a national telescope. It was of course believed, and perhaps rightly so, that the Italian Government was not willing to finance both enterprises. Eventually, priority was given to the national telescope project. This turned out to be a historical mistake. Ironically enough, it is the participation in ESO which will probably permit funding of the Italian national telescope (3.5 m) in the northern hemisphere. However, subsequently many Italian astronomers maintained a strong interest in ESO but no real step forward was taken until late 1977 when for the first time an Italian representative named by the Italian Research Council (CNR) was allowed to participate in the ESO Council meetings as an observer. This was a very important decision which finally led to a meeting between an Italian delegation headed by the Minister of Research and Technology, Mr. V. Scalia, and an ESO delegation headed by the President of Council, Prof. F. Denisse. The meeting took place in January 1980 in the town of Taormina (Sicily), the beautiful and inspiring surroundings of which assisted in the signing of the basic agreement for the participation of Italy. The detailed agreement was ready by May 1980, and on December 19 of the same year the Italian Government approved and sent to Parliament the law establishing the participation of Italy to ESO. The formal approval of the Italian Parliament was obtained on March 2, 1982 and the law published in the "Supplemento ordinario alla Gazzetta Ufficiale No. 92" (Legge 10 Marzo 1982, n. 127).

The hope and wish is that the new membership of Italy will not only satisfy the legitimate wishes of the Italian astronomers and astrophysicists who will now have access to the optical observations in the southern hemisphere, but will also contribute to strengthening the Organization and to further increase its basic role in the development of European astronomy.

Per aspera ad astra! G.S.

With Italy and Switzerland as new members of ESO, the annual contribution level has been increased from 32.5 to 40 million DM and the shares of the contributions of the various countries have changed as follows:

	Before	Shares in %	Now
Belgium	8.81		6.28
Denmark	4.71		3.35
France	33.33		26.75
Fed. Rep. of Germany	33.33		26.75
Italy	–		17.16
Netherlands	11.68		8.33
Sweden	8.14		5.81
Switzerland	–		5.57
	100.00		100.00

The ESO Observing Programmes Committee

B.E. Westerlund, Astronomical Observatory, Uppsala, Chairman of the OPC

Since 1978 the ESO Observing Programmes Committee (OPC) has "the function to inspect and rank the proposals made for observing programmes at La Silla, and thereby to advise the Director General on the distribution of observing time". The members (one from each member country) and their alternates are nominated by the respective national committees for five-year terms (not immediately renewable). The terms are staggered so that each year one or two persons are replaced. The Chairman is appointed annually by the Council. He is invited to attend Council meetings and to report to its members.

The OPC meets as required by the schedule for the award of observing time. It may invite persons from the ESO staff or from among the alternates to attend if required.

The history of the OPC goes back to 1967 when the ESO Council established a Scientific Programmes Committee (SPC). Each of the member countries had a representative, and the Scientific Director of ESO acted as the Secretary and as liaison with the Directorate. The Committee's principal tasks were (1) to advise the Directorate and the Council about the general scientific policy of ESO and (2) to advise the Directorate about the applications for observing programmes of visiting astronomers. The SPC held its first meeting on May 2, 1968.

With respect to its task (2) the SPC proposed rules of procedure which were formally adopted by the ESO Council in its meeting of July 2/3 1968: Allocation of time was to be arranged for intervals of 6 months; applications by visiting astronomers had to be submitted to the Directorate at least 6 months before the beginning of these periods; and the applicant should be informed about the decision by the Directorate about 4 months before these dates. One third of the time was to be allotted to the ESO staff; the SPC was not supposed to advise on these programmes but merely to be kept informed.

During 1968 and 1969 the SPC proposed allocations to the Directorate, but from its meeting in November 1970 it presented ratings of the scientific value of the applications to the Directorate to serve as the base for drawing up a suitable observing schedule.

The importance of ESO and its observatory on La Silla for the European astronomers became soon obvious; during 1971 the amount of time requested in the numerous applications was more than double the amount of time available. The SPC also found it "evident that ESO should contemplate the acquisition of more instruments up to the size of 150 cm diameter".

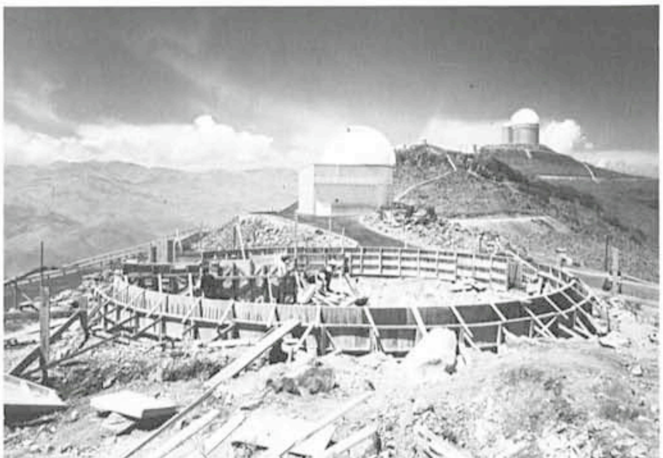
In 1971 the Council decided to establish a Scientific Policy Committee for ESO. The Scientific Programmes Committee accepted "Observing Programmes Committee" as its new name.

In the early days of the OPC (SPC) each application for observing time was reviewed by one of its members who then presented his rating at the meeting for acceptation by the OPC. The applicants were treated in alphabetic order, and as the proposals mostly described the observations desired, not much discussion was necessary. During the first few years practically all proposals were granted observing time. This was possible as the number of proposals was rather low; it was also an ESO policy to have as many European astronomers as possible get acquainted with ESO, La Silla, as soon as possible. From 1971 on, when overdemand for observing time became the normal state of affairs, the OPC has, rather regularly, discussed the general policy to be followed in allotting time.

In 1972 the OPC found it preferable to assign ample observing time to the more outstanding programmes rather than attempt to satisfy more or less all acceptable applications. It also proposed that outstanding programmes should be allotted time "irrespective of nationality". This should be read in the light of the principles in allocating time as explained by the ESO Directorate in the Annual Report 1972: It follows first of all the advice of the OPC, expressed in the scientific rating of the proposals. However, a number of other circumstances are taken into account, such as: oversubscription for certain seasons and a relative scarcity of applications for others; instrumental feasiblility of execution of a programme; and the aim to arrive, in the long run, at relative shares of the available nights approximately proportional to the financial contributions of the Member States.

In 1976 the number of ESO staff astronomers stationed in Europe began to increase appreciably. It was felt that they were more similar to visiting astronomers than to the ESO astronomers directly involved in the operations on La Silla; consequently their applications for observing time ought to be treated in the same way as those by visiting astronomers. After some experimenting the OPC arrived at its present procedure in which all ESO staff applications are evaluated in the same way as for visiting astronomers. Even if by necessity some staff applications may receive a special treatment in the final scheduling—one third of the time is still reserved for the

Determination of the North-South line for the 2.2-m telescope (24. 1. 1982).



The 2.2 m telescope building photographed on April 4, 1982. In the background, the Schmidt and the 3.6 m telescopes.

staff—the OPC knows by its evaluation that the scientific quality of all proposals obtaining observing time is high. The question is, however, still occasionally a hot item at the OPC meetings; due to the increased frequency of joint proposals by ESO staff and visitors the soundness of the present procedure becomes more and more obvious.

During 1978 and 1979 the OPC attempted to express its evaluation also in the number of nights reasonable to allot to a programme. This has now been abandoned; it is left to the Directorate to decide on the number of nights for each programme.

The number of applications for observing time has continued to grow. For the present period, No. 29, beginning on April 1, 1982, 211 applications had been submitted; for period 21, beginning on April 1, 1978, the number was 124. It has become impossible for the OPC to discuss each application in detail and a new procedure had to be developed. From period 23 on the OPC did its evaluations with two of its members reviewing each application for 3.6 m telescope time; this shortened the discussions at the meetings and was found to work so well that it is now applied to all applications.

The applications for observing time are now evaluated in the following way: The OPC members receive them listed by the ESO Visiting Astronomers Section according to subject (there are at present 10 groups covering everything from "galaxies" to "the solar system"). For each application two OPC members have been chosen as referees. Their ratings, which cover the scientific quality of the proposal and also consider its requests in the likelihood of a reduction in time, are sent to ESO well before the OPC meeting. The complete list of ratings is given to the OPC members, usually on arrival at Garching. Those applications for which the two referees have arrived at the same ratings need not be discussed much further, and the OPC can concentrate on those where discrepancies occur. The discussions may be very extensive in these cases, and they continue until a unanimous decision has been reached. Occasionally it may happen that an OPC member, who was not a referee for a particular application, disagrees with a proposed rating; then the application will be extensively discussed. This is most likely to happen in the intercomparison of applications of similar nature within the various subject groups with the aim of reaching the highest possible degree of fairness.

Among particular questions that have been dealt with in the OPC the long-range programmes have often been on the agenda. Should special programmes be allotted observing time in advance for several observing periods? In 1971 the OPC decided not to attribute a certain percentage of time to long-range programmes in order to keep sufficient flexibility for handling short-term projects. Normally, a long-range programme once found acceptable would in principle be allocated telescope time over several observing periods; it would, however, in each period be in competition with the other applications submitted. These principles are still followed, and it may be stated that special attention is paid to all programmes that have a tendency to become long range; they have to show progress and it has to be made convincingly clear that more material is really needed. In deciding this the OPC has to rely on the information given in the completed application forms, in particular on the report over previous observations. It may be said in this connection that most applications are nowadays very well written with the scientific aim well presented and the feasibility of the observations clearly established. The importance of a superb Abstract on page 1 of the form should be emphasized.

At all its meetings the OPC discusses the activities on La Silla. Reports on the condition of telescopes and auxiliary instrumentation are presented and discussed as well as other matters of importange for the observing programmes. Thus, for instance, the OPC has recently considered the large number of change-overs of auxiliary instrumentation—in one year almost 200 change-overs had occurred, not including minor items such as changes of filters, multipliers, IR detectors, etc.—and decided to support the Technical Research Support Group on La Silla by recommending as large a reduction of change-overs as feasible without limiting the flexibility for observers unreasonably much; keeping instrumentation on the telescopes for longer periods will improve its performance.

The OPC has also at a recent meeting recommended that the limits for stoppage of observations be reviewed. It was felt that much observing time would be gained by even a very slight increase in the limits now applied for wind velocity and humidity.

The OPC recommended already in 1972 that observational material collected at La Silla and of interest to other astronomers, after analysis by visiting astronomers at their home institutes, be centralized in Europe. At that time the material under consideration consisted mainly of photographic plates. Now, with much material available in digitized form only, on magnetic tape, this question will have to be reconsidered and a new kind of storage problem faced.

As a consequence of its main function, the OPC obtains a clear picture of the progress in optical astronomical research in the ESO member countries. As the proposals frequently describe how the observations planned for La Silla are supported or supplemented by observations in other spectral ranges—X-ray, UV or radio—this picture becomes rather complete. I may conclude by saying that even if the OPC members may feel the pressure of evaluating twice a year about 60 proposals each, they also feel greatly stimulated by reading the high-quality scientific rationales and far-reaching aims that are presented nowadays. They certainly also share the gloom expressed sometimes in a "no-progress" report: "The weather was too bad", and most definitely prefer to read "Results published in . . .".

Age and Metal Abundance of a Globular Cluster, as Derived from Strömgren Photometry

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Introduction

The age of the universe is a cosmological parameter of fundamental importance. When compared to the Hubble constant, H_0, the age can in the standard Big Bang model inform us about the large-scale structure of the universe, i.e. whether the universe is open or closed. Alternatively, such a comparison may reveal that the two parameters are not compatible, so that either the standard Big Bang model is wrong or something is wrong in the methods by which the age and H_0 are determined.

A lower limit to the age of the universe can be obtained from the ages of globular clusters—the oldest objects known in our galaxy. Their ages are determined from the position of turnoff stars in an effective temperature-luminosity (T_e-L) diagram. These stars represent the phase of stellar evolution for which nearly all of the hydrogen at the centre of the star has been burned by nuclear reactions. The turnoff stars are leaving the main sequence and on their way toward the red-giant branch. The temperature and luminosity, at which this happens for a given cluster, depend strongly on the age of the cluster.

Turnoff stars in globular clusters are quite faint—even in the nearest clusters. Typical magnitudes are V = 16-20. Temperatures and luminosities are therefore usually determined from broad-band BV photometry, the calibration of which is rather difficult. Some of the problems encountered are the determination of interstellar reddening and the calibration of the B-V colour index in terms of T_e. However the most severe problem is which metal abundance to use for the cluster, because the position of the theoretical isochrones in the T_e-L diagram depends critically on this parameter. Usually one takes the value derived from photometry or spectroscopy of red giants in the cluster, but unfortunately we cannot be sure that this value applies to turnoff stars. The chemical composition in the atmospheres of the giants may be affected by mixing of elements produced by nuclear reactions in the stellar interior. Furthermore, the metal abundance of the giants in some clusters—e.g. ω Cen—show a dispersion of about a factor of 10. In other cases the metal abundances derived from photometry and spectroscopy do not agree. For 47 Tuc the photo-

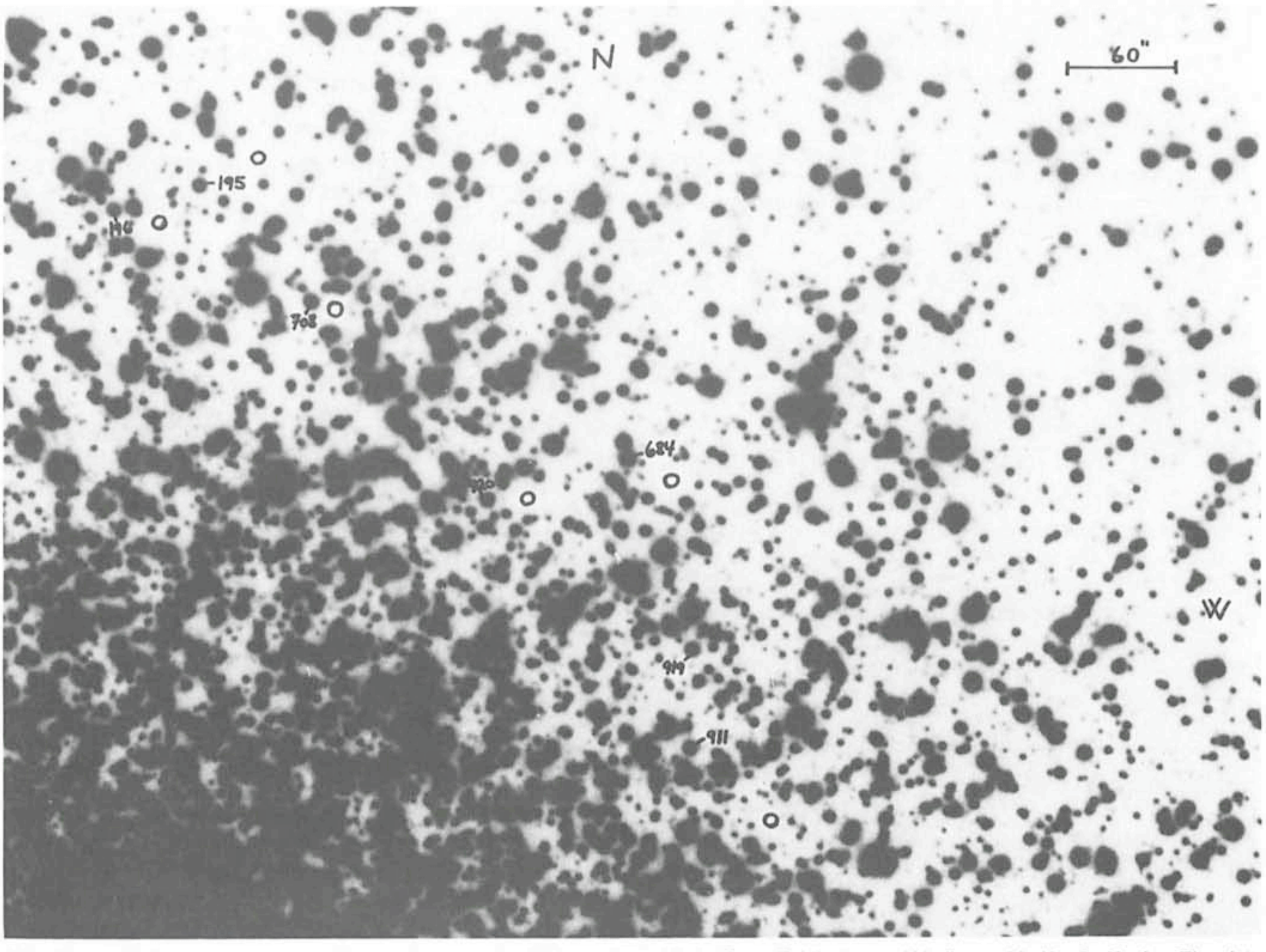

Fig. 1: *Part of the globular cluster NGC 6397 from a 10-min V plate taken with the Cerro Tololo 4-m and kindly provided by G. Alcaíno. The plate limit is around 21 mag. The picture illustrates the main difficulty of doing photoelectric photometry in globular clusters: the crowding of stars. All turnoff stars which are sufficiently separated from neighbouring stars are marked by numbers. The sky backgrounds measured are encircled.*

metry leads to a value of [Me/H] = −0.5, whereas recent high-dispersion spectroscopy gives [Me/H] = −1.2. Here the symbol [Me/H] denotes the logarithm of the metal-to-hydrogen ratio of a star minus the same quantitiy for the sun. Thus the two results differ by a factor of 5. If the high value is adopted for the turnoff stars, an age of $10 \cdot 10^9$ years is derived for 47 Tuc, whereas the low metal abundance leads to an age of about $25 \cdot 10^9$ years.

The case of 47 Tuc shows that the accuracy of age determination of globular clusters needs considerable improvement before a detailed comparison with H_0 can be carried out. Furthermore an important question relating to the formation and evolution of our galaxy remains unsolved: Do all globular clusters have the same age or do they show an age range of say $10 \cdot 10^9$ years. The first case corresponds to a rapid collapse of the protogalaxy and the latter case to a collapse time that is comparable to the lifetime of the galactic disk.

With these problems in mind and aiming at more accurate determinations of ages and abundances of globular clusters the author has, in collaboration with A. Ardeberg, initiated a programme of photoelectric uvbyβ photometry of turnoff stars in globular clusters. In the following I shall report on the first results obtained for one of the clusters and discuss the accuracy of the age and other parameters which can be determined. We shall see that the advantage of using the Strömgren system is that the reddening, metal abundance, and age can be directly determined from the photometry of the turnoff stars.

Observations

The first cluster selected was NGC 6397—the second nearest globular cluster. The uvbyβ observations were carried out with the single channel photometer at the 3.6-m telescope during two nights in July 1981. Transformations to the uvbyβ standard system were established by observing a number of standard stars in the magnitude range $8.0 < V < 11.0$. The rms scatter in the transformations is of the order of 0.01 mag for the colour index b-y, the metal-line index m_1, the Balmer-discontinuity index c_1, and the β index that measures the strength of the Hβ absorption line.

The selection of turnoff stars in NGC 6397 was based on photographic BV photometry by Alcaíno and Liller (1980). Fig. 1 shows part of a 10-min V plate taken with the Cerro Tololo 4-m and kindly provided by G. Alcaíno. It illustrates the problem of crowding of stars. Generally it is impossible to carry out accurate photometry with an entrance diaphragm less than 5 arcsec in diameter, and in the centre of the cluster the average distance between stars is much less. One is therefore forced to observe in the outer regions of the cluster, where a higher fraction of the stars will be non-members.

A list of stars to be observed in NGC 6397 was selected by the criteria $16.0 < V < 16.7$ and $0.40 < B\text{-}V < 0.65$. This corresponds to the upper part of the turnoff region in the colour-magnitude diagram. The region contains about 100 stars. However, a star was included in the final observing list only if it appeared perfectly round on the photographic plate, and if the field within a radius of 10 arcsec around the star was not contaminated by other stars brighter than the plate limit, V = 21. This condition reduced the observing list to 19 stars, all of which were observed using a diaphragm of 7 arcsec in diameter. Two of these stars turned out to be non-members according to their position in the c_1-(b-y) diagram (see later). The sky background was measured in regions where no stars brighter than 21 mag occurred within 10 arcsec from the diaphragm centre (see Fig. 1). In order to count a suitable number of photoelectrons for each filter, a total integration time

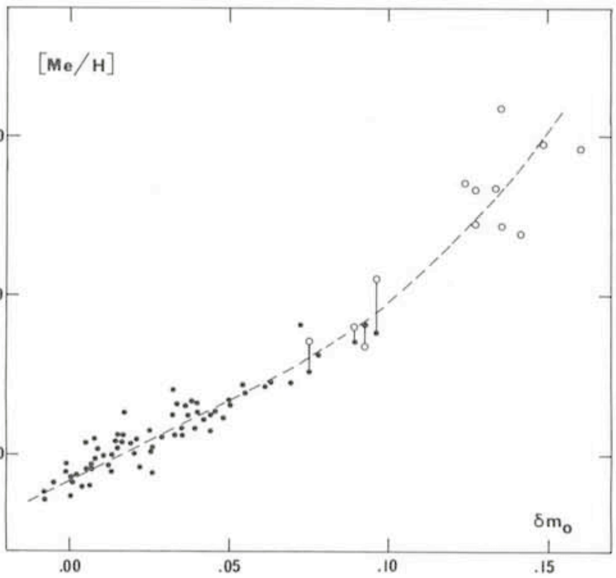

Fig. 2: *Calibration of the Strömgren δm_o index as a function of the logarithmic metal-to-hydrogen ratio, [Me/H].* • , *[Me/H] values from Nissen (1981).* ○ , *[Me/H] from Carney (1979). Stars in common are connected by vertical lines.*

of about 20 min per star was needed. From repeated observations the mean error of the indices b-y, m_1 and c_1 is estimated at 0.02-0.03 mag. The largest contribution to this error is due to fluctuations in the seeing, which was not particularly good (2–3 arcsec). For the β index the error is higher (of the order of 0.04 mag) because of the relatively small number of photons observed through the narrow filter.

As described in more detail in the ESO Users Manuel, the star field around the diaphragm in the 3.6-m photometer can be seen by reflection through the TV viewing system in the Cassegrain adapter. This facility made it fairly easy to identify the stars, centre the right star or sky in the diaphragm, and keep it there during the integration by guiding on another star. Furthermore, an on-line photometric reduction system, recently made by F. Gutiérrez, was of great help.

Reddening

As we shall see later, it is of crucial importance for the age determination of a globular cluster to have an accurate value of its reddening. It is for this purpose that the β index, which is unaffected by interstellar reddening, was observed.

In the spectral range, A5-G2, both the b-y colour index and the β index are good indicators of effective temperature. For unreddened stars we therefore expect a close relation between the two indices. This has been confirmed empirically by Crawford (1975), who found that the relation is slightly dependent on metal abundance. For reddened stars we can therefore use the observed β index to calculate the intrinsic colour index, $(b\text{-}y)_0$.

Application of this method to the turnoff stars in NGC 6397 yields an average colour excess of $E(b\text{-}y) = 0.14 \pm 0.02$. This value is slightly higher than the value of $E(b\text{-}y) = 0.11$ found from photometry of horizontal branch stars, but agrees very well with a recent reddening value based on ultraviolet data.

The Metal Abundance of NGC 6397

The metal-line index m_1 is defined as a colour index difference $m_1 = (v\text{-}b) - (b\text{-}y)$ which means that it is not very much affected by interstellar reddening. A careful study by Crawford

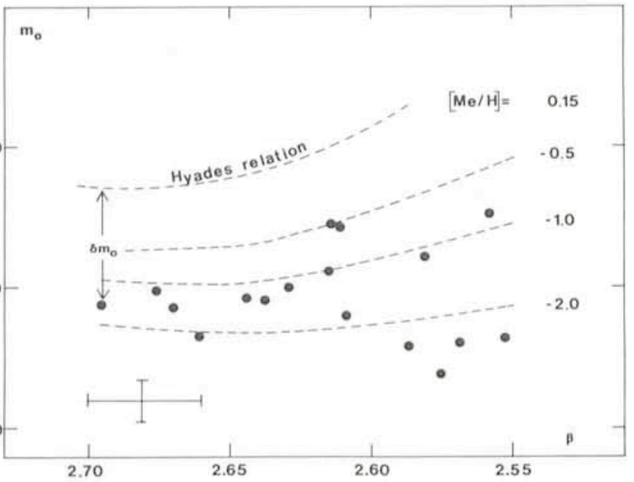

Fig. 3: *The $\beta - m_o$ diagram for turnoff stars in NGC 6397. The observed relation between β and m_o for the Hyades is drawn, and the definition of δm_o is shown for one of the stars. Curves corresponding to constant values of [Me/H] are given. Interpolation between these curves leads to an average metal abundance of [Me/H] = -1.6 ± 0.2 for NGC 6397. The error bars indicate the mean errors of the indices.*

and Mandwewala (1976) shows that the excess of m_1 is given by $E(m_1) = -0.32 \cdot E(b\text{-}y)$. We can then compute the dereddened metal-line index $m_0 = m_1 + 0.32 \cdot E(b\text{-}y)$, using $E(b\text{-}y) = 0.14$.

The number of metallic absorption lines in the v band is much higher than the number of lines in the b and y bands. We therefore expect the m_o index to depend on metal abundance. m_o also depends somewhat on temperature. However, by introducing the difference between m_o for the Hyades and for a star, the so-called δm_o index (see Fig. 3), we obtain an index which is less temperature dependent. Fig. 2 shows a calibration of δm_o in terms of [Me/H] for the spectral region corresponding to the turnoff stars. Indeed there is a rather good correlation between δm_o and [Me/H].

Using the calibration of δm_o shown in Fig. 2 and taking into account a slight temperature dependence of δm_o, we can calibrate the β-m_o diagram in terms of [Me/H], i.e. draw the curves of constant [Me/H] (see Fig. 3). In the same figure the NGC 6397 stars are plotted. It is seen that they fall well below the Hyades relation, which indicates that their metal abundance is much smaller. The average metal abundance of NGC 6397 is found to be

$$[\text{Me/H}] = -1.6 \pm 0.2,$$

which means that the metal-to-hydrogen ratio is a factor of 40 lower than the ratio in the sun. Assuming that the fractional weight abundance of elements heavier than helium, Z, is proportional to the metal-to-hydrogen ratio we get

$$Z_{\text{NGC 6397}} = 0.0004,$$

where we have used $Z_{sun} = 0.017$. This result is about a factor of 2 higher than the heavy element abundance found from spectroscopy of giant stars in NGC 6397.

The Age of NGC 6397

The c_1 index is defined as $c_1 = (u\text{-}v) - (v\text{-}b)$, and the dereddened index is given by $c_0 = c_1 - 0.20 \cdot E(b\text{-}y)$. The u band is centered at 3500 Å and the v band at 4100, which means that c_0 is sensitive to the size of the Balmer discontinuity at 3650 Å. Thus for a given value of $(b\text{-}y)_o$, c_o is a measure of the surface acceleration or luminosity of stars. The $(b\text{-}y)_o$–c_o diagram can therefore be used to derive effective temperatures and luminosities of stars. In this respect the diagram is equivalent to a traditional HR-diagram.

Fig. 4 shows the $(b\text{-}y)_o$–c_o diagram for NGC 6397. The zero-age main sequence (ZAMS) for Pop. II stars has been determined as the lower boundary of the distribution of field Pop. II stars. A number of these stars have recently been observed in the Strömgren system with the 50-cm and the 150-cm Danish telescopes on La Silla.

As mentioned earlier, membership can be estimated from the position of the stars in the $(b\text{-}y)_o$–c_o diagram. Two stars, well separated to the left of the main group of stars, are considered non-members and have been omitted.

$(b\text{-}y)_o$ has been calibrated in terms of T_e by model atmosphere computations of R. Bell and B. Gustafsson. Such computations give reliable data for the *change* of $(b\text{-}y)_o$ as a function of T_e and [Me/H]. The zero point is determinded from the (b-y) index of the sun.

In order to compute the bolometric magnitude, $M_{bol} = -2.5 \log L + \text{const}$, we first introduce the quantity δc_o (see Fig. 4). From a study of nearby stars with accurate trigonometric parallaxes, Crawford (1975) has shown that δM_{bol}, defined as M_{bol} (ZAMS) – M_{bol}, is linearly correlated with δc_o. The coefficient is 10 for late F-type stars, i.e. $\delta M_{bol} = 10 \cdot \delta c_o$.

By using the calibrations of $(b\text{-}y)_o$ and δc_o, we can now find the distribution of NGC 6397 stars in the $T_e - \delta M_{bol}$ diagram (Fig. 5). In the same diagram theoretical isochrones corresponding to 10, 16 and $25 \cdot 10^9$ years are drawn. The isochrones have been computed by Hejlesen (1980). It is seen that the $25 \cdot 10^9$ year isochrone gives a fairly good fit to the distribution of stars. A comparison with isochrones recently computed by D.A. VandenBerg, University of Victoria, leads to an age of $22 \cdot 10^9$ years. Thus independent computations of isochrones agree very well. However, before we compare the age of NGC 6397 with H_o, we shall briefly discuss the most important possible errors in the age determination.

The Uncertainty of the Age Determination

Several problems contribute to the uncertainty of the derived age of NGC 6397:

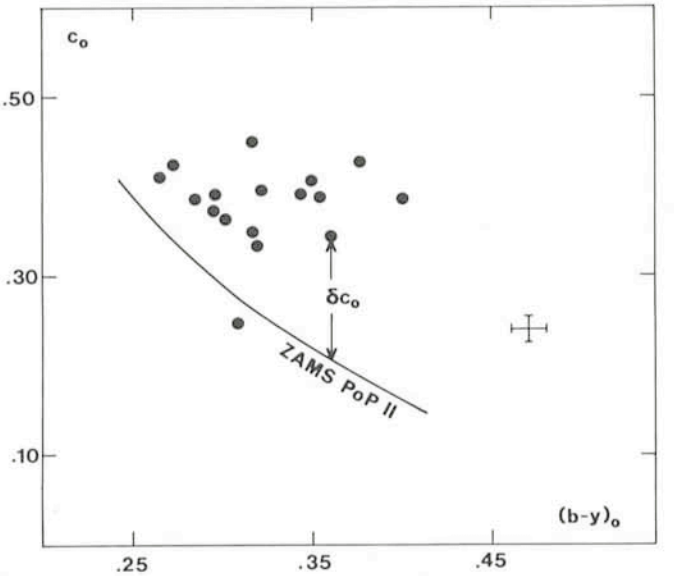

Fig. 4: *The $(b\text{-}y)_o$ – c_o diagram for turnoff stars in NGC 6397. This diagram is equivalent to an HR diagram. $(b\text{-}y)_o$ can be converted to effective temperature and c_o to luminosity.*

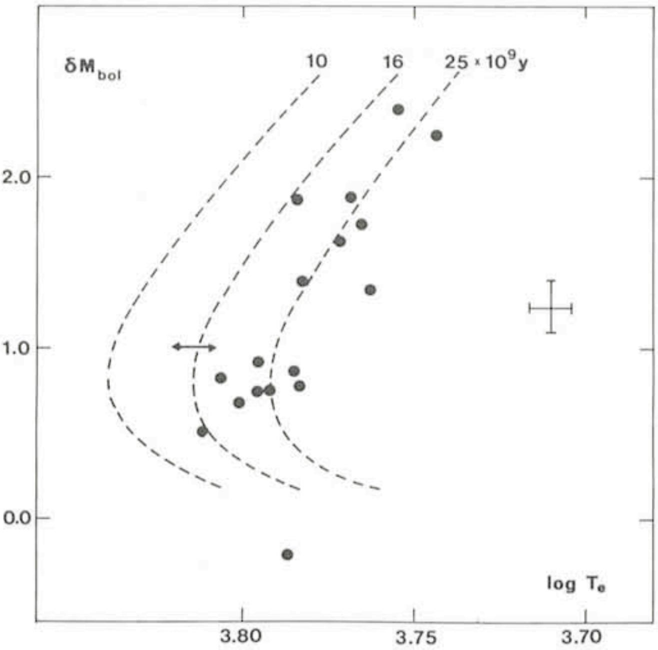

Fig. 5: *The log T_e – δM_{bol} diagram for turnoff stars in NGC 6397. The definition of δM_{bol} is given in the text. Isochrones corresponding to ages of 10, 16 and $25 \cdot 10^9$ years have been computed by Hejlesen (1980). A helium abundance of $Y = 0.20$ and a metal abundance of [Me/H] = –1.6 have been adopted. The log T_e shift of the isochrones corresponding to $\Delta Y = 0.1$ is indicated by the left arrow. The shift corresponding to Δ[Me/H] = 0.2 is given by the right arrow.*

Error bars indicate the errors of log T_e and δM_{bol} inferred from observational errors. Within these errors there is a fairly good fit to the $25 \cdot 10^9$ years isochrone. Systematic errors of the age determination are discussed in the text.

(i) The interstellar reddening may be wrong by $\pm 0^m.02$. This converts to an error of $\pm$ 0.01 in log T_e and as seen from Fig. 5 the corresponding error of the age is $\pm 4 \cdot 10^9$ years.

(ii) The zero point of the b-y calibration could be wrong by up to 0.02 mag. In the present calibration a colour index for the sun, $(b\text{-}y)_\odot = 0.395$, was adopted. Some recent investigations give a value of $(b\text{-}y)_\odot = 0.415$, which would decrease the age determined by about $4 \cdot 10^9$ years.

(iii) The error of the metal abundance is ± 0.2 in [Me/H]. As seen from Fig. 5 the corresponding error of the age is $\pm 2 \cdot 10^9$ years.

(iv) In the age determination we have assumed the weight fraction of helium to be $Y = 0.20$. However, it could be as high as $Y = 0.30$. This would increase the age by about $2 \cdot 10^9$ years.

Comparison with the Hubble Constant

From the error discussion above we conclude that the age of NGC 6397 lies between 16 and $25 \cdot 10^9$ years. Thus a lower limit for the age of the universe deduced from this particular cluster is $16 \cdot 10^9$ years. Other recent investigations of globular clusters, e.g. Sandage and Tammann (1981), have also resulted in similar high ages. It is therefore of interest to make a comparison with determinations of H_o.

It is a well-known result from Friedman models of the universe, that for a given value of H_o, the age is a function of the present mass density, ϱ_o. In Fig. 6 the age has been plotted as a function of $\Omega = \varrho_o / \varrho_c$, where ϱ_c is the critical density, for various values of the Hubble constant. $H_o = 52$ km/s/Mpc is the value recently found by Sandage and Tammann (1981) from a study of distances and recession velocities of 16 type-I supernovae. $H_o = 95$ is the value found by Aaronson et al. (1980) from distances of galaxies derived by the Tully-Fischer method. Both determinations refer to galaxies at distances well beyond the Virgo cluster. The values should therefore represent the *global* value of H_o.

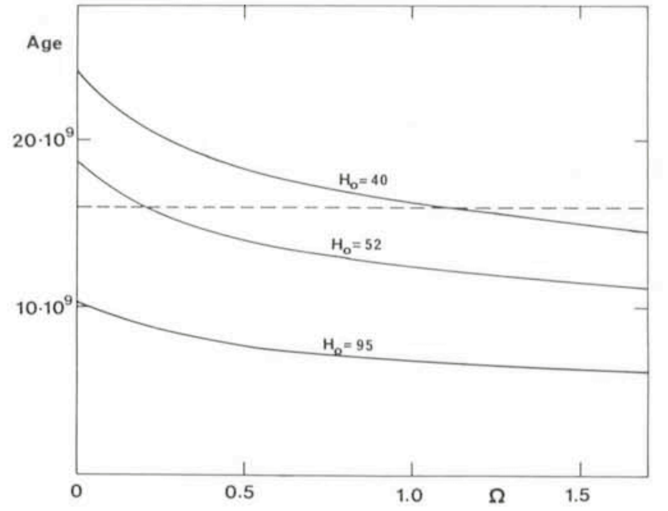

Fig. 6: *The age of the universe in years as a function of the density parameter Ω for various values of the Hubble constant. The horizontal line indicates the lower limit for the age of the universe as derived from the age of NGC 6397.*

It is seen from Fig. 6 that $H_0 = 52$ is consistent with the age limit of $16 \cdot 10^9$ years if $\Omega < 0.2$, which corresponds to an open universe. On the other hand there is a large discrepancy between the age limit and the value of H_o found by Aaronson et al.

Finally, Fig. 6 shows that a Hubble constant, $H_o \leq 40$ km/s/Mpc, is compatible with a closed universe, i.e. $\Omega \geq 1$. Such a low value of H_o cannot be totally excluded in view of the present uncertainty of the value of H_o.

The discussion above illustrates why it is interesting to determine accurate ages of globular clusters. We think that Strömgren photometry of turnoff stars provides an important method for this purpose, a method which in many respects is more accurate than BV photometry. The final cosmological conclusions should await improvement in the calibration of the photometry and further observations of other globular clusters.

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Second ESO Infrared Workshop

About 70 external participants in addition to ESO staff met from 20th–23rd April 1982 to discuss a variety of topics ranging from the infrared work going on at major ground-based observatories to proposals for future space missions. Although mainly devoted to technical aspects, the rapid progress in instrumentation and facilities made in recent years was best demonstrated by the sample of astronomical results obtained at Calar Alto, CFHT, ESO, TIRGO, UKIRT and with aircraft and balloon-borne telescopes which were reviewed by some of the invited speakers. The major trend in future instrumentation was evident from the large number of presentations on array detectors and their application in infrared imaging, spectroscopy and speckle interferometry. An impressive illustration that these devices are already beginning to revolutionize observational possibilities came in the form of 2D "photographs" at 10 μm shown of such old infrared favourites as the BN/KL complex in the Orion Nebula and NGC 7027.

The main theme of the Workshop, explored during several discussion sessions, was the future relationship between ground-based, air-borne and space observations. Of immediate general interest in this area was the question of how best to provide the follow-up observations necessary to fully exploit the IRAS all-sky satellite survey due to start later this year. Although heated at times, this discussion unfortunately only served to confirm that any coordinated approach on the ground during the survey itself is likely to prove extremely difficult for a number of reasons. It also became clear, however, that much of the desired follow-up will in any case have to await the even higher sensitivities promised by other cold space telescopes such as GIRL and, hopefully, ISO and SIRTF. These facilities offer unparalleled opportunities for a wide range of infrared observations.

Even these facilities cannot fully exploit the astronomical potential of the entire infrared waveband, however, and there appears good reason to believe that other projects such as the VLT (probably an array of 8–10 m diameter telescopes) being studied by ESO, the European Astroplane, the Large Deployable Reflector being studied by NASA and even possibly the Space Telescope promise equally exciting prospects for Infrared Astronomy in the future.

It is intended to publish the Proceedings of the Workshop which will hopefully be available in September/October 1982.

A.F.M.M

Study of the Large Magellanic Cloud with the Fehrenbach Objectiv-Prism

Ch. Fehrenbach, M. Duflot, R. Burnage and the radial velocities staff of the Marseille and Haute-Provence Observatories

The 40 cm Objective-Prism (GPO or Grand Prism Objectif in French), now at La Silla, had first been used in the Southern Hemisphere, at Zeekoegat, in South Africa. ESO, then looking for a site for its observatory, had accepted its installation on one of the tested sites.

It is Ch. Fehrenbach who, as early as in 1958, thought that the detection of the members of the Large Magellanic Cloud (LMC) from their radial velocity (RV) would be well suited to the GPO then operating at the Haute-Provence Observatory. Indeed, because of its velocity relative to the Galaxy and of its galactic longitude of about 280°, the stars of the LMC have a RV of the order of 250 km s^{-1}, well outside the range of RV of the galactic stars.

The Fehrenbach's POs are mainly built for the measurement of radial velocities. With the GPO it is possible to measure the RV of all stars brighter than magnitude 13 in a $2 \times 2^\circ$ field; so the LMC supergiants are measurable. Sixteen fields are needed for a proper coverage of the LMC.

The first plates, obtained in 1961, showed the efficiency of the method. A first list of 102 stars, probable members of the LMC, was published in 1964 (Duflot et al.) and about one hundred were added in 1965 (Fehrenbach et al.). At the present time, one last catalogue (in press) of stars known to be members of the LMC from their RV, contains 711 stars.

During this study, we have discovered a group of LMC stars having abnormal spectral characteristics of a type unknown in our Galaxy. These stars have abnormally strong hydrogen lines (Fehrenbach and Duflot, 1972). Similar stars have since been found by other astronomers in the Small Magellanic Cloud.

On the other hand, we have been surprised to find in the direction of the LMC a large number of galactic stars with a large radial velocity, in the 100–350 km s^{-1} range (same reference).

Our work was not limited to the detection of the LMC stars; we have also measured the RV of all the stars appearing on our plates, either in the LMC or galactic. To achieve this, it has been necessary to get a large number of plates: 6 to 9 for each field. Many of these plates have been obtained in Chile after the move of the GPO from Zeekoegat to La Silla where it is now, being taken care of by ESO.

The measurements made at the Marseille Observatory with a spectrocomparator (Compelec) do not have the same accuracy as the one obtained by the Haute-Provence Observatory group; there, the plates are measured by a correlation method (Mesucor). However, the density of stars and nebulae on the LMC plates is very large and the Mesucor is not suited to this work. Only an experienced eye can detect the lines in spectra which are generally blended with other spectra, blurred in nebulae or at the limit of detection; stars called CON in the HD catalogue. In a paper in press, the accuracy is estimated to be 11.5 km s^{-1} for the Compelec measurements, which is good enough for a statistical study.

We have now at our disposal radial velocities for 418 stars in the LMC and for 2,560 galactic stars in the direction of the LMC.

We have made the following observations:

1. For two regions of the LMC, the velocity dispersion is significantly different:

Region I: the densest part is at about 5^h32^m, $-67°10'$ and the velocity dispersion is about 18 km s^{-1}.

Region II: The densest part is at about 4^h55^m, $-69°40'$ and the velocity dispersion is about 48 km s^{-1}.

These two regions are about symmetrically placed with respect to the centre of the LMC and could correspond to the neutral points of the de Vaucouleurs and Freeman (1972) theory: region I stable, region II unstable.

2. The histograms of the distribution of the galactic RV (Fig. 1) show maxima in agreement with the velocity of the Sun toward its apex. In the west of the LMC and even more in the south-west, another strong maximum appears at about 45 km s^{-1}. Is it a group of more distant stars?

Let us note that the systematic study of the plates has allowed us to build

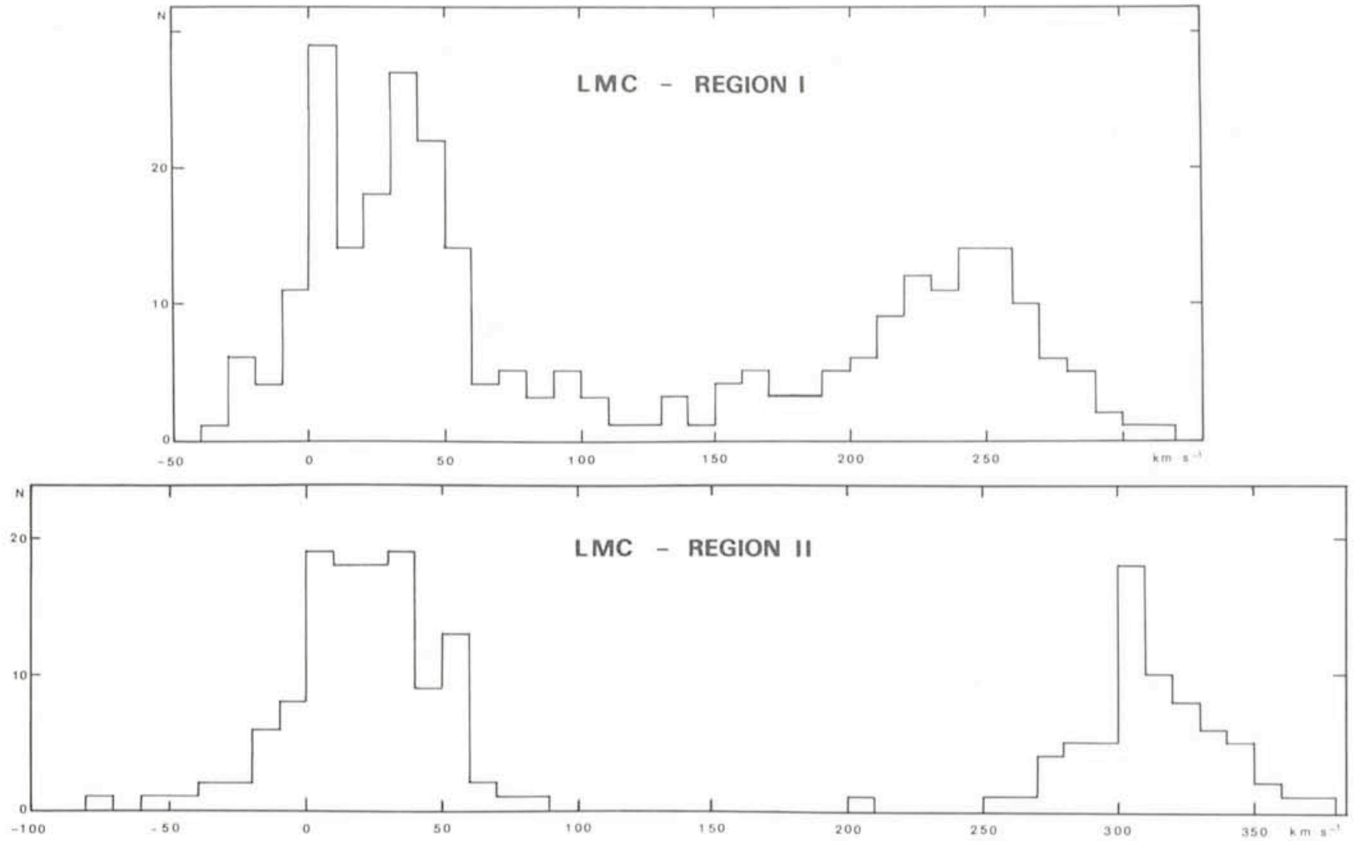

Fig. 1: *Radial velocity histograms in regions I and II. The peak at small velocities, which appears at about the same location in the two fields, represents galactic stars. In contrast, the peaks corresponding to the LMC stars are at very different velocities in the two regions; this difference is due to the rotation of the Large Magellanic Cloud.*

(1) a catalogue of WR stars (Fehrenbach et al. 1976)
(2) a list of star-like or small emission-line objects, planetary nebulae or H II regions (Fehrenbach et al. 1978). We have described the spectral characteristics of some of them.

In addition we have found a galactic star showing very strong CH bands and having a RV of 450 km s^{-1}.

The study of the LMC itself is now almost finished but we are presently studying several fields at –30° galactic latitude to find out if the number of high velocity galactic stars is larger in the direction of the LMC than in other directions.

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TAURUS – The Imaging Fabry-Perot at La Silla

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During August–September 1981 TAURUS, a scanning Fabry-Perot system used in conjunction with the University College London Image Photon Counting System, was installed at the Cassegrain focus of the 3.6 m telescope at La Silla. It was used in a variety of programmes, all requiring velocity information as a function of position in extended objects, such projects being especially suited to this type of observing technique. Programmes included velocity structure in barred spiral galaxies, velocity structure in merging and interacting "active" galaxies, velocity structure in supernova remnants, including an attempt to measure the velocity structure of the Fe XIV 5303 emission N 49, a SNR in the LMC.

TAURUS, an imaging Fabry-Perot system, was developed as a collaborative project by the Royal Greenwich Observatory and Imperial College London (*Monthly Notices of the Royal Astronomical Society* **191,** 675, 1980; *M.N.R.A.S.* in press) and is capable of obtaining seeing-limited velocity field information over a 9 arcminute field on a 4 m telescope. At the detector (the IPCS) the image of the source is modified by the fringe pattern of the capacitatively stabilized servo-controlled Fabry-Perot. As the Fabry-Perot is scanned, this fringe pattern tracks radially across the field and each pixel of the detector maps out a spectral line profile within the bandpass of the "blocking" interference filter. At each F-P spacing a picture (200 × 200

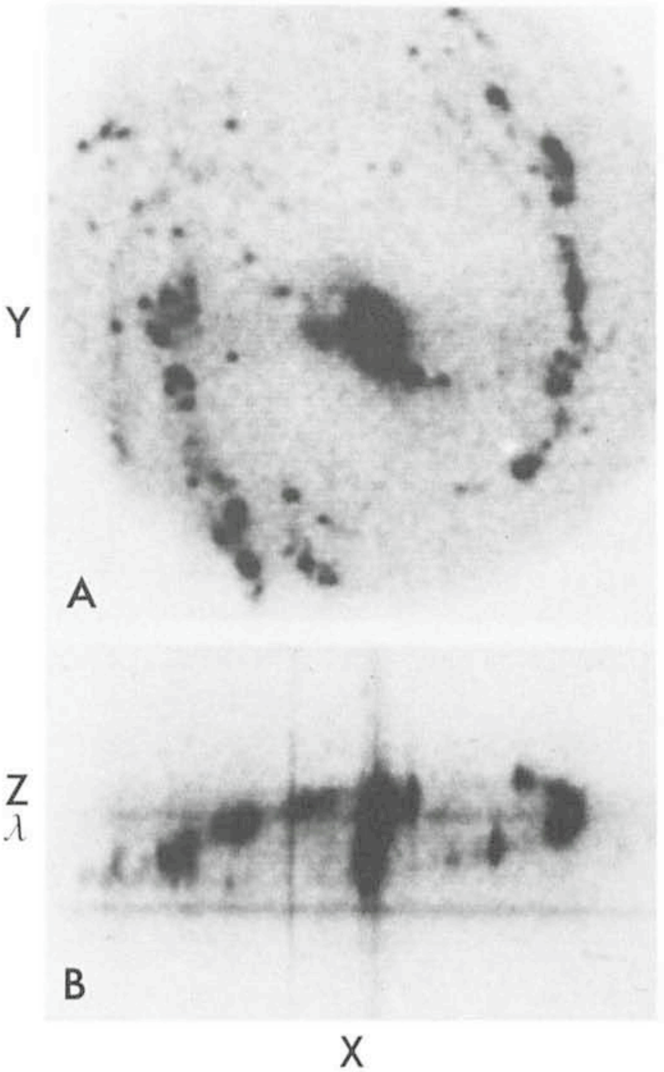


Fig. 1 *illustrates the data obtained for the barred spiral galaxy NGC 1365. A is an image of NGC 1365 resulting from compacting the cube in the Z (or λ) direction. Therefore it contains images of NGC 1365 over a velocity range of 1,000 km/sec at a wavelength corresponding to Hα. B results from compacting the data cube in the Y direction and therefore shows velocity as a function of X position (in this case right ascension) over the whole galaxy. The vertical straight lines in B represent the continua of stars in the field, while the horizontal streaks are night sky features. The ellipsoidal structure in B traces the regular large-scale rotational motion of the H II regions in this galaxy.*

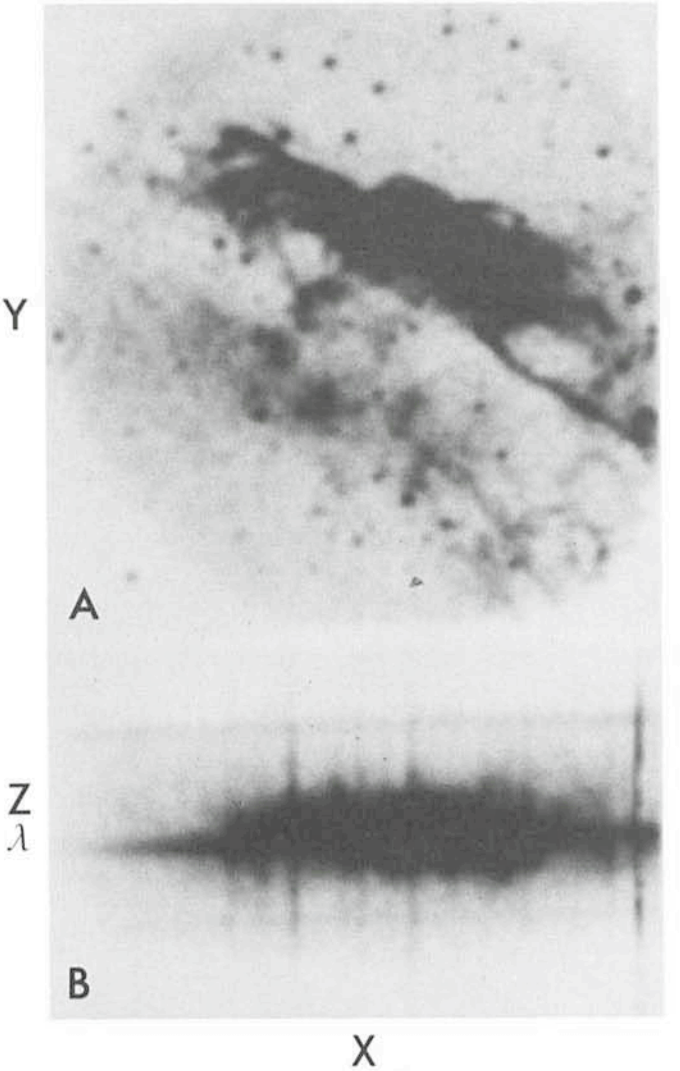


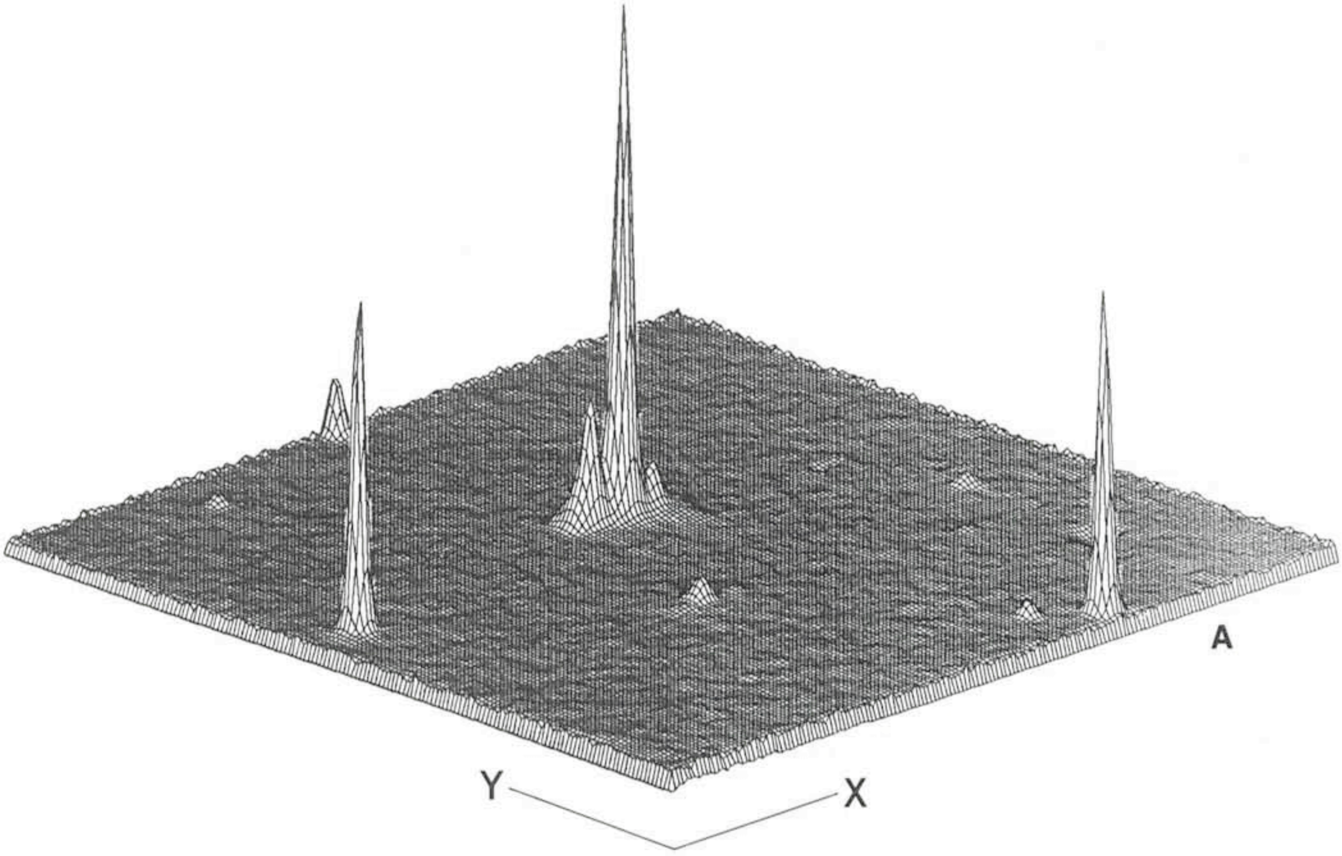
Fig. 2 *is a similar illustration for the southern filament of the SNR RCW 103 observed at a wavelength corresponding to [O III]5007. In Fig. 2B one can see many vertical straight lines representing stellar continua. One can also see a region of broad emission corresponding to a velocity range of several hundred kilometres/second. This of course corresponds to the large random turbulent motions generated by shock waves in supernova remnants of this age and size. At either end of the range in X one begins to see a much narrower range of velocity corresponding to positions outside the main filament and probably corresponding to a surrounding H II region. One can note this correspondence with Fig. 2A.*

pixels) is recorded on computer disk. 100 pictures make up a complete scan, covering for example 1,200 km sec^{-1} free spectral range (this range in practice depends on the particular etalon). In this manner a 3 D data cube of the field is built up where (X, Y, Z) are typically (200 pixels, 200 pixels, 100 steps).

If we plot the intensities recorded by 1 pixel through the scan range, we see the spectral line profile for that part of the object being observed. Because the light from different parts of the field passes through the etalon at different angles, there is a shift in the wavelength zero-point as a function of field angle. Because of this the (X, Y) pictures of raw data are not monochromatic. This positional dependence of wavelength is calibrated and then corrected for by shifting each profile in the computer so as to line up the zero point at all (X, Y) positions—a process known as phase correction. The phase corrected data cube has X, Y as spatial dimensions and Z as a wavelength dimension, i. e. more than 4 Megabytes of information. These data are then analysed by viewing, X, λ or Y, λ plots or as a "movie" of a rapid sequence of (X, Y) pictures as a function of λ, enabling us to view different parts of the objects at different velocities. By summing all the pictures in λ we may produce the equivalent narrow band interference filter pictures, as if the Fabry-Perot were not in the system. By scanning in X or Y we may produce an X, λ or Y, λ plot similar to the display of 2D long slit spectra. In these, night sky lines should appear straight across the field, indicating the accuracy of the phase-correction process.

It is worth stressing that an IPCS is an essential component of this instrument because of the photon-counting capability, fast readout, negligible instrumental noise and large detector format.

A. Boksenberg, J. Fordham, K. Shortridge and R. Hook participated in these projects and contributed substantially towards their success, as did the support of the ESO staff at La Silla, especially J. van den Brenk.



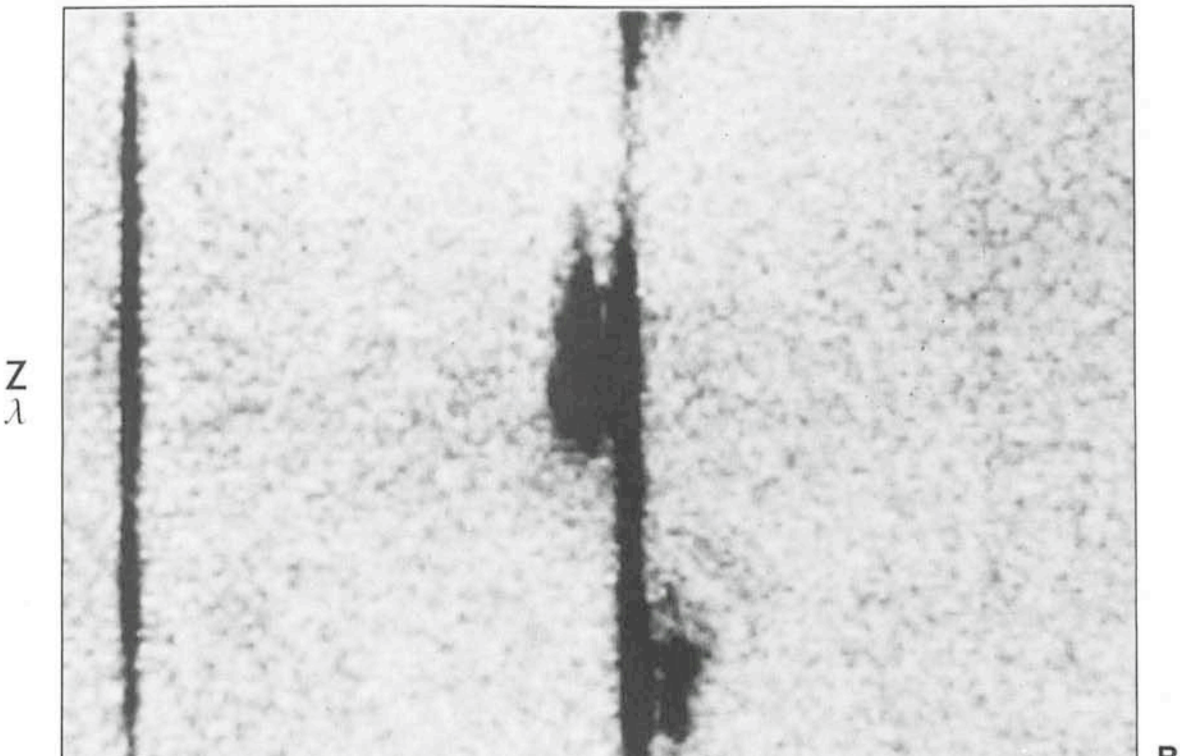


Fig. 3 A *represents a wavelength compacted [O III]5007 image of the radio galaxy PKS 2158-38. This manner of displaying the data shows all of the [O III] emission at various velocities and as well gives an idea of the relative strengths as a function of position on the sky. The galaxy causes the triple peaked structure in the centre of the field. Other peaks in the field are caused by stars.*

Fig. 3 B *is an X-velocity plot (compacted in Y) similar to those described for previous figures. It shows the variation of velocity as a function of right ascension position, and one can note in particular the steep velocity gradient across the nucleus so characteristic of PKS 2158-38.*

Radial Velocity Observations with the 36″ Telescope at Cerro San Cristobal, Santiago, Chile

C. Sterken, Astrophysical Institute, Brussels, and N. Vogt, Universitäts-Sternwarte, München

Around the end of last century there was an urgent need for systematic determinations of radial velocities of southern stars. W.W. Campbell at Lick Observatory therefore organized an astronomical expedition with the aim to install an observatory with a radial velocity telescope in Chile. D.O. Mills provided the funds to make a replica of the Lick Observatory 36″ telescope, and donated the dome and expedition costs.

A 850 m high hill in a chain near Santiago was selected as observatory site, mainly for the adequate location and the presence of logistic support from the town of Santiago. The expedition was initially planned for three years (1902–1905), but the interesting results prompted the initiators to keep the station functioning until 1928. The results were published in the famous radial velocity catalogues in the Lick Observatory Bulletins.

In 1928 Manuel Foster bought the observatory and donated the instruments and the building to the Universidad Católica de Chile. At that time, the 36″ telescope was still the largest one operating in the southern hemisphere, and the tenth all over the world. During the following two decades astronomers of the Catholic University (especially Dr. Erich Heilmeier) used the telescope for spectroscopy of β Cep stars and other variables. However, increasing technical and economic problems forced them to shut down the observatory in 1948, and for more than 30 years the telescope was not used for scientific purposes. In 1980 it was put again into operation with the original one-prism Cassegrain spectrograph mounted. Also telescope and dome are still in their original form of 1902, but perform satisfactorily (Fig. 1).

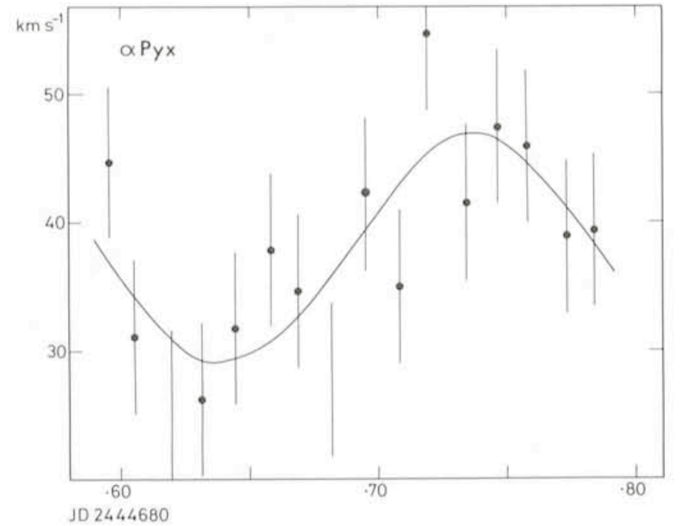


Fig. 2: *Radial velocity curve of α Pyx.*

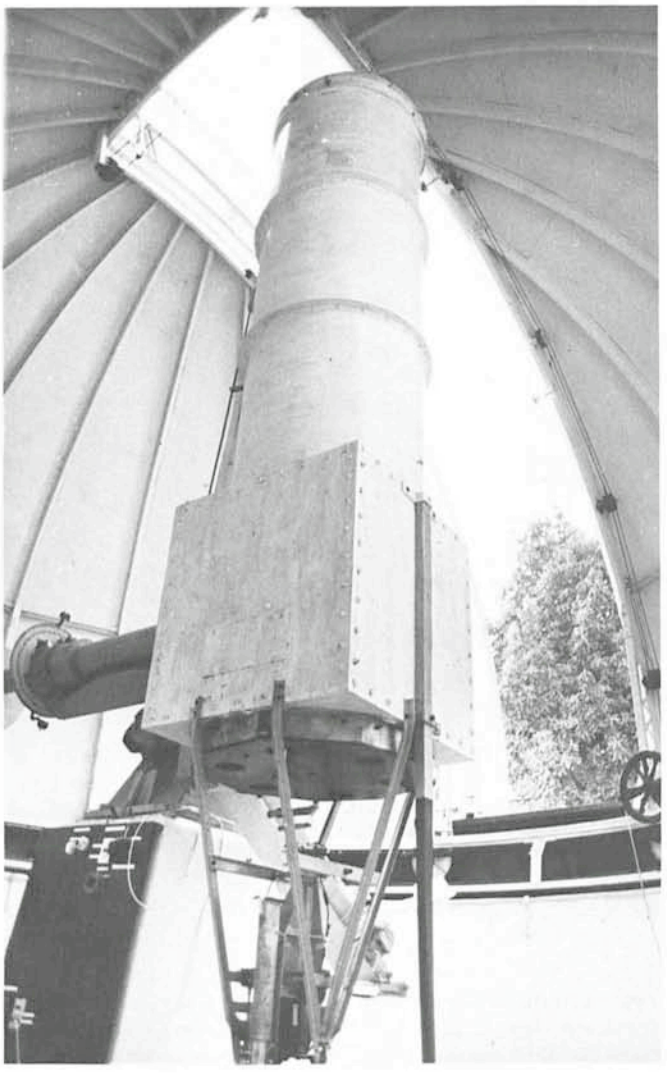


Fig. 1: *The 36″ Mills telescope at Cerro San Cristobal, Santiago, Chile. (Photograph by C.E. Le-Cerf.)*

The telescope has a main mirror of 92.9 cm diameter, and a focal ratio of f/18. On IIa–O plates a spectral range 3900–5000 Å can be covered. The dispersion at Hγ is 36 Å/mm. The exposure time for a 7^m star with 0.5 mm widening is typically of the order of 1 hour. Even for larger exposures up to 3 hours no influence of the city light of Santiago can be noticed in the spectrograms.

Several observing programmes are now executed in collaboration with the Instituto de Astrofísica at the Universidad Católica. The main subjects are observations of RS CVn stars, WR stars and β Cephei stars. The last programme consists of systematic observations of the brightest β Cephei stars and β Cephei candidates. During a photometric search for new β Cephei stars amongst the southern B stars listed in the Bright Star Catalogue (see i.e. the *Messenger,* No. 11, p. 5–7, 1977), M. Jerzykiewicz and C. Sterken found several new β Cephei stars. Some stars, however, are too bright to be observed photometrically (i.e. ζ CMa, α Pyx), or have a companion which is too close (HR 3142–3143, 17″ separation) to allow accurate differential photometry. Bright stars are excellent targets for the Mills telescope, because monitoring bright stars optimizes the ratio exposure time to pointing time. Until now hundreds of plates have been taken of objects such as ζ CMa, α Pyx, τ CMa, δ Cru, etc. All plates are secured by Gaston Le-Cerf Basulto and Esther-Maria Acunã, two technicians from the Universidad Católica.

The plates are sent to Garching monthly, and are measured on the Grant machine by one of the authors. Fig. 2 illustrates the radial velocity curve of α Pyxidis on the night of March 16/

17, 1981. The data points represent the mean value of the heliocentric velocity of the He 4143, 4388 and 4471 lines, and the solid line is the least squares sine curve fitted to the individual points. The mean error on each point is estimated to be of the order of 5–6 km s^{-1}. The range of radial velocity variation is about 20 km s^{-1}, and a probable period of .19 day (approximately 5 hours) is obtained from the fit. uvbyβ photometry of α Pyx yields a β-index β = 2.606 and a reddening corrected temperature index Co = .034, values very representative for a β Cephei star. The quasi-sinusoidal radial velocity variation found on JD 2444680 seems to support the suggestion that α Pyx is a reliable β Cephei candidate. The final evaluation of all available plates will probably give more indications concerning its nature. A detailed study of the star will be undertaken using the 1.5 m telescope at La Silla in 1983.

It is clear that the frequent use of an instrument like the Mills telescope may contribute enormously to increase the efficiency of searches and surveys and it may give important hints for planning observational research at larger telescopes. In addition, it offers the possibility of extended spectroscopic runs, allowing to follow the same star for several weeks or months. This kind of programme can never be executed at La Silla or similar observatories with a tight visitors schedule. Finally, simultaneous photoelectric (La Silla) and spectroscopic (San Cristobal) observations of brighter stars over relatively large time intervals would also be of great scientific interest, as shown above by means of the β Cephei candidates.

There is some hope that the actual one-prism spectrograph may be replaced by a modern fast instrument in the future. Such a development would surely encourage European observers to apply for observing time.

A New and Interesting Seyfert 2 Galaxy: NGC 5728

M.-P. Véron, P. Véron, M. Tarenghi and P. Grosbøl, ESO

NGC 5728 is an SBb galaxy; its galactocentric radial velocity is 2,710 km s^{-1} with H_0 = 50 km s^{-1} Mpc^{-1}, its distance is 54 Mpc and 1″ = 262 pc. The central structure of NGC 5728 is curiously asymmetric; a high luminosity nucleus sits within a high-surface brightness ring (dimensions 7″.5 × 10″.0 or 2.0 × 2.6 kpc); but the nucleus is displaced from the centre towards the east (Sandage and Brucato 1979, *Astronomical Journal* **84,** 472; Rubin 1980, *Astrophysical Journal* **238,** 808).

Within 2 arcsec of the nucleus, strong lines of Hα, [N II], [S II] and [O III] are observed, with [N II]λ6584 marginally stronger than Hα; weaker lines are also present ([O I]λλ6300, 6364 and [Ar III]λ7136); in the nuclear region, the Hα and [N II] emission lines are split into multiple components; the emissions continue beyond the nucleus through the region of the nuclear ring. Nuclear emission is intense; emission from the ring is weak. (Rubin 1980; Sandage 1978, *Astron. J.* **83,** 904).

According to Rubin, the velocity distribution in the ring can be fitted with a model with rotation plus axisymmetric expansion; this model implies a constant rotational velocity near V = 300 km s^{-1} and an expansion velocity decreasing from 275 to 150 km s^{-1} from r = 0.65 to r = 1.3 kpc and to zero at r = 2 kpc (r is the distance from the centre). Simple energetic considerations show that velocities radial from the nucleus with V ~ 250 km s^{-1}, decreasing to zero near 2 kpc imply a nuclear mass (r < 2 kpc) ~ 1 × 10^{10} $M_\odot$; this value agrees well with the mass deduced from the rotational velocities.

A spectrum exposed for 20 minutes, obtained on 12 August 1980, with the Image Dissector Scanner (IDS) and the Boller and Chivens spectrograph attached to the 1.5 m ESO telescope at La Silla, with a dispersion of 171 Å mm^{-1} (resolution ~ 10 Å FWHM) and a 4 × 4 arcsec aperture shows that the nucleus has the Seyfert 2 characteristics: [N II] λ 6584 ~ Hα and [O III] λ 5007 ≫ Hβ (Fig. 1).

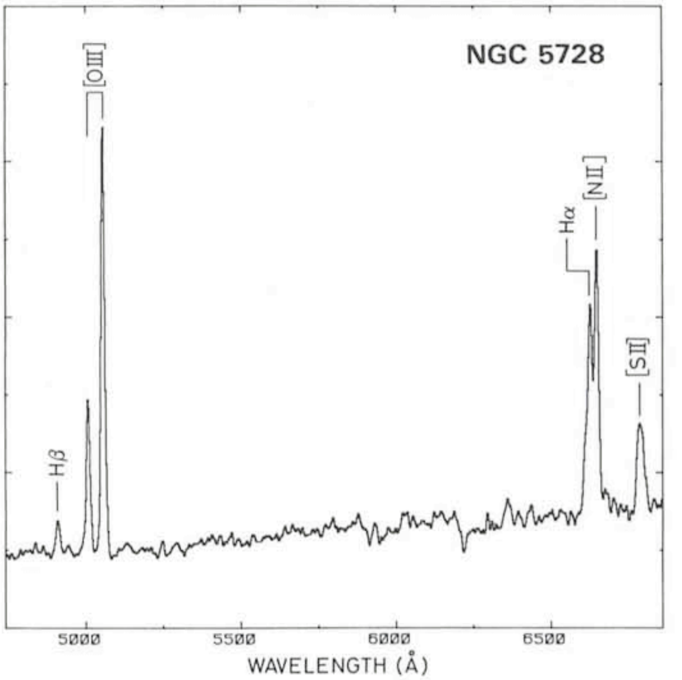


Fig. 1: *Spectrum of the nucleus of NGC 5728 obtained with the Image Dissector Scanner and the Boller and Chivens spectrograph attached to the 1.5 m ESO telescope. The resolution is about 10 Å. This spectrum shows that NGC 5728 has a Seyfert 2 nucleus.*

The heliocentric radial velocity of the emission lines as measured on this spectrum is V = 2,760 km s^{-1}, close to the systemic velocity measured by Rubin, V_0 = 2,800 km s^{-1}.

Two spectra have been obtained with the IDS and the Boller and Chivens spectrograph at the ESO 3.6 m telescope, on 10 February and 5 August 1980, with a dispersion of 29 Å mm^{-1} (giving an instrumental profile of 1.6 Å FWHM), with a 2 × 4 arcsec aperture (with the large dimension in the EW direction), in the spectral range 4600–5100 Å. The emission lines (Hβ and [O III] λλ 4959, 5007) have a simple profile, with broad wings; their FWHM is 350 km s^{-1}. The radial velocity of the peak of these lines is V ~ 3,000 km s^{-1} (Véron 1981, *Astronomy and Astrophysics* **100,** 12).

More recently, on 23 March 1982, we observed again this nucleus with the 3.6 m telescope, in the red. The dispersion was 60 Å mm^{-1}, the aperture 4 × 4 arcsec. On this spectrum, all lines are double with a separation of about 10 Å; the radial velocity of these two components is 2,520 and 3,000 km s^{-1} respectively (Fig. 2).

This seems to indicate that the gas in the nucleus has a radial velocity of 3,000 km s^{-1}, larger by 200 km s^{-1} than the systemic

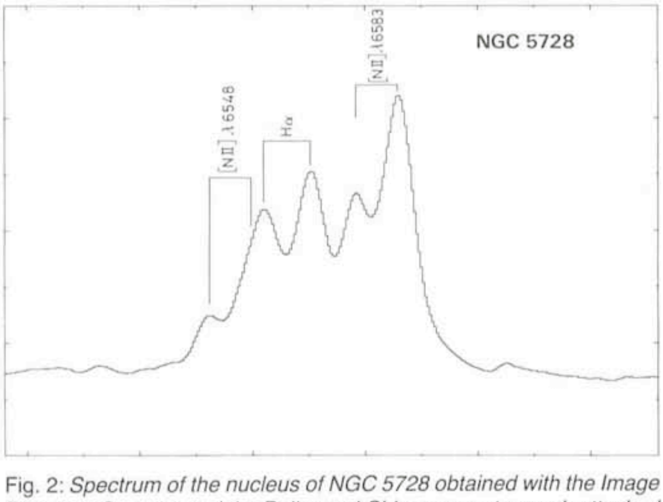


Fig. 2: *Spectrum of the nucleus of NGC 5728 obtained with the Image Dissector Scanner and the Boller and Chivens spectrograph attached to the 3.6 m ESO telescope. The aperture was 4 × 4 arcsec, the resolution about 4 Å. The double structure of the emission lines is clearly seen.*

velocity. The second, low velocity component, which is seen with a 4 × 4 arcsec aperture, but not with a 24 arcsec aperture, probably originates in the part of the ring which is close to the nucleus. A remarkable fact is that, in both components, [N II] λ 6584 > Hα, indicating that the material in the ring has the ionization characteristics of Seyfert nuclei rather than being ionized by hot stars.

We have obtained two 10-minute exposures of the nucleus of NGC 5728 with the ESO CCD attached to the Cassegrain focus of the Danish 1.5 m telescope at La Silla; one was through a r filter (λ_o = 6580 Å, FWHM ~ 900 Å) containing the strong emission lines of Hα, [N II] and [S II]; the second through an i filter (λ_o = 8190 Å, FWHM ~ 1880 Å) filter which avoids all emission lines of any significant strength. Fig. 3 is a subtraction of these two pictures (r – i) showing the emission nebulosity; this picture is similar two those of Rubin and Sandage and Brucato, although it shows more details. This nebulosity has sharp outer edges, but material is seen everywhere inside it, suggesting that it is an envelope rather than a ring.

Making use of the measurement of the velocity field by Rubin, we may conclude that it is an expanding asymmetrical envelope. It may even be that there is no gas in the nucleus and that the gas seen in the direction of the nucleus in fact comes from the far side of the shell.

A detailed study of the dynamics of this envelope of gas would certainly be of interest and could shed some light on the ill understood complex profiles of the emission lines in the nucleus of active galaxies (Heckman et al. 1981, *Astrophys. J.* **247,** 403). TAURUS, the Fabry-Perot imaging device of the Imperial College, London (Atherton et al., this issue) seems to be well suited for such a study.

The nuclear nebulosity of NGC 5728 is in some ways qualitatively similar to the Crab Nebula. The Crab Nebula is a somewhat ellipsoidal volume, about 4 pc in diameter (if its distance is 2 kpc), partially filled with emission filaments; this volume is expanding with a velocity at its outer surface of about 1,500 km s^{-1} with respect to the centre. The emission line spectrum has the same main characteristics as the Seyfert 2 galaxies, including NGC 5728; the filaments are most probably radiatively ionized by the non thermal continuum filling the volume of the nebula. The loss of rotational energy by the central pulsar is an adequate supply for the energy requirements of the nebula (~ 2 × 10^{38} erg s^{-1}) (see for instance IAU Symposium No. 46, 1971, "The Crab Nebula"). The NGC 5728

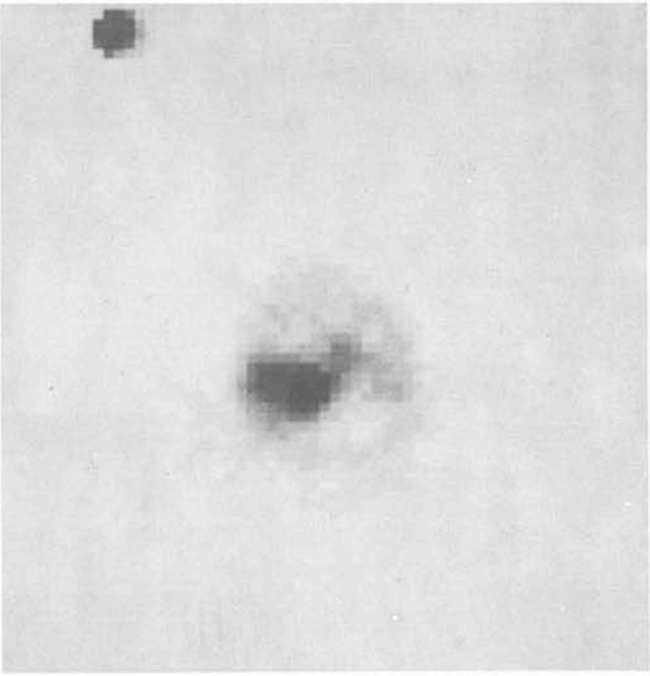


Fig. 3: *Difference of a red and an infrared CCD picture of the nuclear region of NGC 5728, showing the emission nebulosity. Its total NS extent is about 10 arcsec.*

nebulosity is almost 3 orders of magnitude larger than the Crab's one; its expansion velocity is much smaller but it has been decelerated in the gravitational field of the nucleus; the energy is several orders of magnitude larger. The origin of the ultraviolet ionizing continuum and the source of energy are still unknown.

List of Preprints Published at ESO Scientific Group

191. R.M. West and A. Kruszewski: Distant Clusters of Galaxies in the Southern Hemisphere. A Status Report. *Irish Astronomical Journal.* March 1982.
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Variable K-type Stars in the Pleiades Cluster

F. Van Leeuwen, Royal Greenwich Observatory, and P. Alphenaar, Leiden Observatory

As a result of an extensive astrometric and photometric study of the Pleiades cluster it was found that a high percentage of its K-type stars are variable. These variabilities may provide new insights in the problem of redistribution of angular momentum.

The first indications for this variability were obtained from a photometric survey of all known or suspected members of the cluster. This survey was carried out in November 1979 using the Dutch 91 cm telescope on La Silla equipped with the Walraven five-channel photometer (Lub, 1979: *The Messenger,* **19,** 1). Because variabilities can provide valuable information on the internal structure of stars, we applied for new observing time in 1980 and 1981.

The Photometric Observations

The photometric observations were again performed using the Dutch 91 cm telescope. During two seasons (October-November 1980 by Van Leeuwen and Alphenaar and October-November 1981 by Alphenaar and Meys), 3 late G- and 16 early K-type stars were investigated. At the start of the investigation only an indication for variability of these stars was available, but after completing our seond run, all 19 stars were known to be variable and for 11 of them we had established light-curves and periods. This was made possible by reducing all measurements within 24 hours after obtaining them and incorporating all available information in the planning for the coming night. In 1980 we used for this purpose an HP 41C pocket calculator but in 1981 the reduction programme for the Walraven photometry was finished and could be used at the computer centre on La Silla. The amount of extra work to be done by the astronomers is considerable, but only in this way can one be sure to get the best use of the telescope time, especially in studying periodic variability. In addition, the excitement of discovering variable stars, finding their periods, plotting their light-curves, and looking for clues to their behaviour makes up for a lot of the extra work.

The observations were performed in two periods of three weeks. During the first week the selected stars were measured several times per night each in order to check on their variability and the time scale on which this variability takes place. Using those results, the second week was spent obtaining fractions of the light curves and determining periods. The third week was used to fill in the uncovered parts of the light-curves.

The Photometric Interpretations

The light-curves we found, as shown in Figs. 1a-e, are similar to those of BY Draconis stars. These stars are supposed to be pre-main-sequence stars in their final contracting stage towards the main sequence. The main characteristics of BY Dra stars are: (a) spectral type dKe or dMe, (b) periodic variabilities with periods of a few days and amplitudes up to 0.4 magnitudes, (c) emission lines of Ca II and H. The source of the variation is usually sought in rotational modulation.

Except for the period, which is of the order of several hours, the characteristics of the 9 stars in Figs. 1a-c, which will be called 'v' type, are the same as observed for many BY Dra stars. The shape of the light-curves are similar: smooth, only one maximum and one minimum, and often asymmetric. Those shown in Fig. 1d which show broad minima and will be called 'u' type, and those of Fig. 1e, which show broad maxima and will be called 'n' type are less frequently observed. Like many BY Dra stars some of the Pleiades K-type stars are known as flare stars (Haro, 1976: *Ton. Obs. Bull.,* **2,** 3).

The light-curves shown in Fig. 1 are sorted on period, with different symbols for the 1980 and 1981 observations. When we examine Figs. 1a-c, over increasing periods, the first star encountered is Hz 1883. (The star numbers come from the Catalogue of the Pleiades by Hertzsprung [1947: *Leiden Annalen* XIX, 1 part A].) This star with its very stable and smooth light-curve has the shortest period and largest amplitude (0.20 magnitude in V) of all. It is followed by the possibly disturbed light-curve of Hz 686 (1980 observations) and the smooth light-curves of Hz 3163, 1531 and 882. These stars have amplitudes around 0.11 magnitude and periods from 10 to 14 hours. The third group consists of two light-curves, those of Hz 1124 (1981) and 879, both having amplitudes around 0.07 magnitudes and periods around 22 hours. Finally, there is Hz 34 with an amplitude of 0.03 magnitude and a period of 28 hours. A similar light-curve is possibly also shown by Hz 1039. Figure 1d shows a similar behaviour for the stars with a broad minimum, viz. Hz 25 and Hz 1332 and Fig. 1e for those with a broad maximum, viz. Hz 2034, Hz 686 and Hz 1124. The data presented in Fig. 1 show a relation between amplitude and period, as well as with the shape of the light-curves. Those shown in Fig. 1e all have smaller amplitudes than those of Figs. 1a-d for similar periods. This effect was especially notable for Hz 686, which showed a V-shaped light-curve with large amplitude in 1980 and an n-shaped one with smaller amplitude in 1981. The period-amplitude relation is shown in Fig. 2, in which the stars of Figs. 1a-c are indicated by 'v', those of Fig. 1d by 'u' and those of Fig. 1e by 'n', all according to the shape of the light-curve.

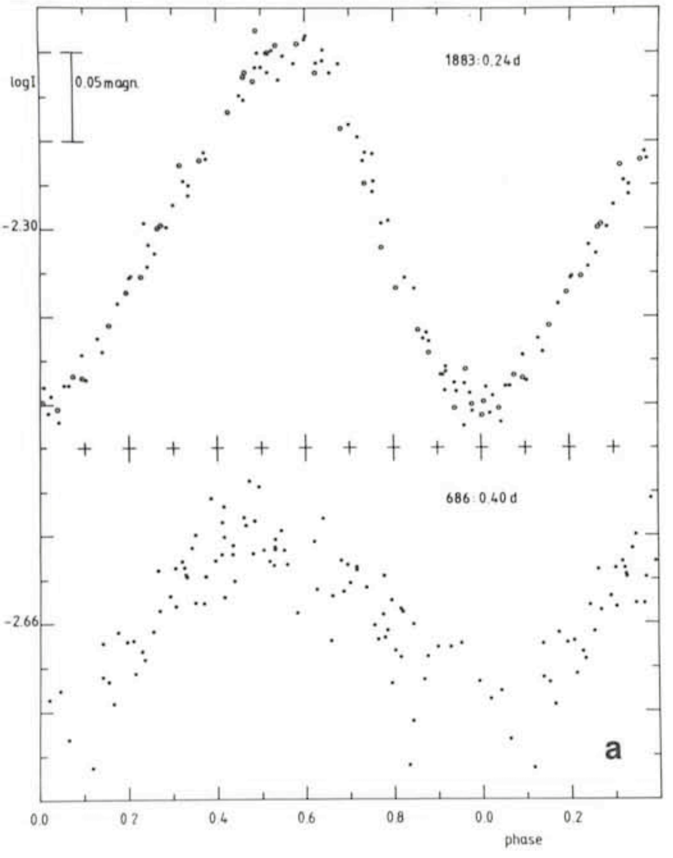
Fig. 3 shows the V-(V-B) relation for K-type members of the Pleiades cluster. For star Hz 1883 the direction and size of its variations are also indicated. This direction appears to be the same as the relation between V and (V-B) of all stars together, which is the relation for normal stellar atmospheres of stars on the main sequence. This could mean that the appearance of Hz 1883 changes as if we see a normal stellar atmosphere with the accompanying surface and mass. Its variations do not take place along lines of constant radius. A calculation showed that the effective surface of the star is about 6 ± 1.2 per cent larger at maximum than at minimum light.

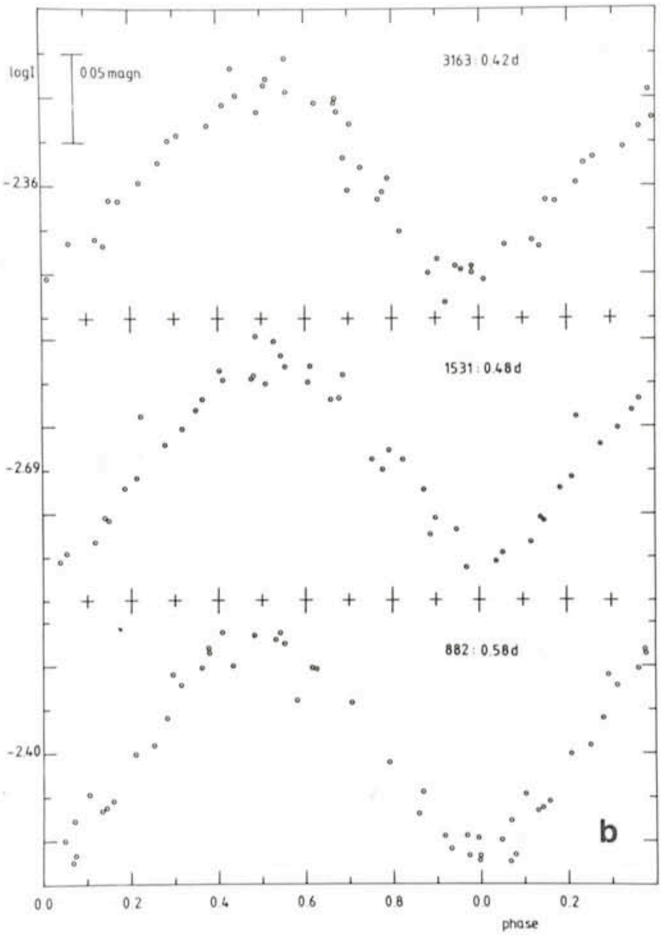
The Spectroscopic Observations

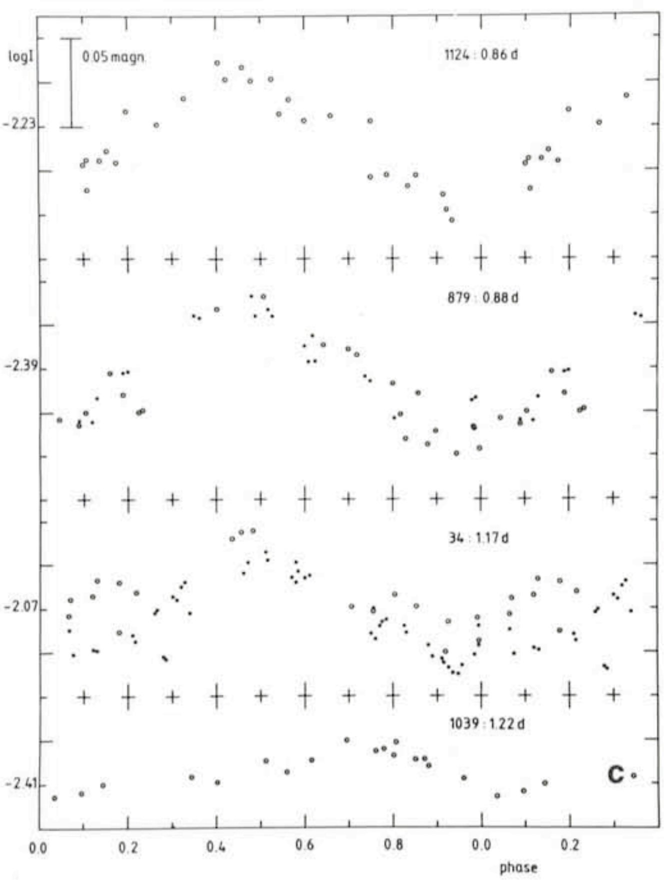
In addition to the photometric observations, spectroscopic data were obtained for two stars, viz. Hz 1883 and Hz 3163. These observations were performed at Lick Observatory by Dr. M. F. Walker, using the 120 inch reflector and coudé spectrograph.

In December 1980, four time-resolved spectra were taken of Hz 1883, using the resolution of 115 Å/mm. These spectra showed no double lines or significant changes in radial velocity, which means that this star is most probably single. The spectrum was determined as K3Ve. Line profile measurements obtained for the same star in October 1981 showed a rotational velocity of 150 km/sec, which is extremely high for a K-type star.

A similar result was found for star Hz 3163. Spectra taken in December 1981 showed a rotational velocity of 75 km/sec. The ratio between the rotational periods and the photometric periods for Hz 1883 and Hz 3163 are almost the same.







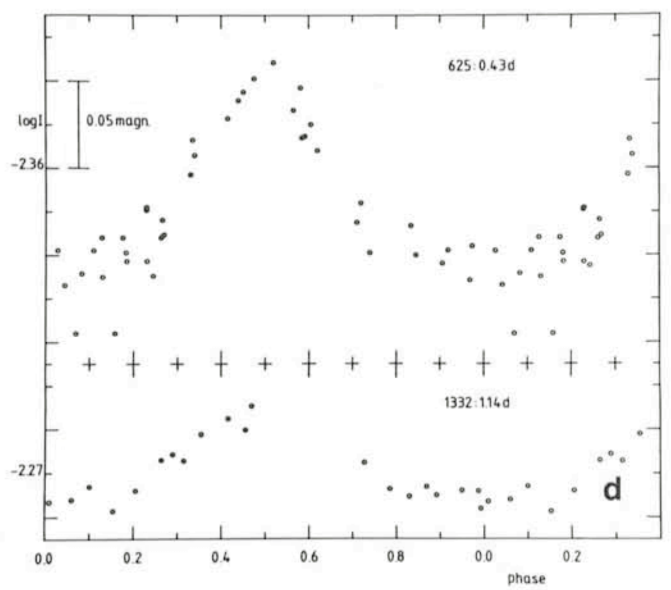
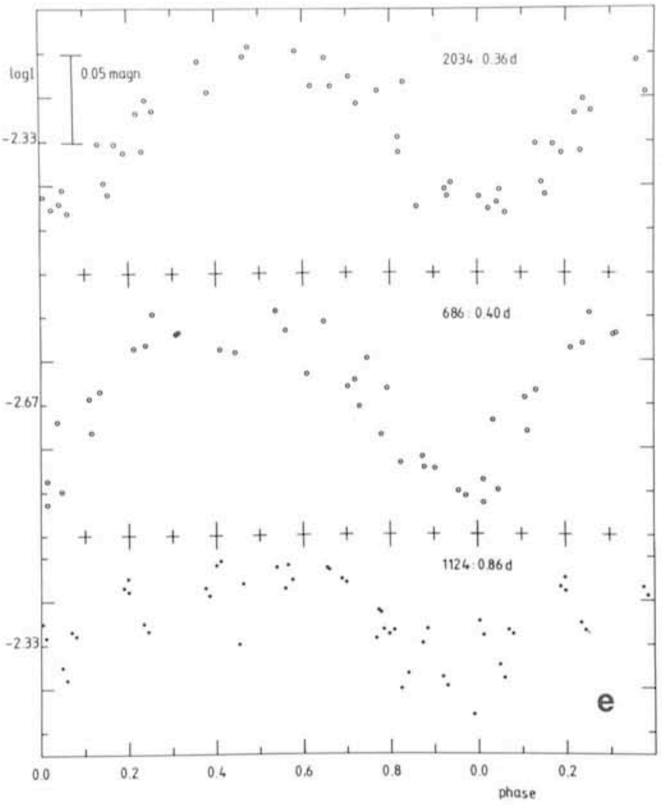


Fig. 1a-1e: *The light-curves for the stars measured so far, sorted on type (1a-1c: 'v' type, 1d 'u' type and 1e 'n' type) and on period.*

Moreover, the rotational period would be close to the photometric period for such high rotational velocities, an effect which is also observed for other BY Dra stars. It will therefore be assumed that the photometric and rotational periods are proportional for the Pleiades K-type stars, and that the photometric variations are probably due to rotational modulation.

Rotational Modulation

Rotational modulation is caused by inhomogeneous luminosity distribution over the stellar surface, which can be due to spots or to non-axial symmetry. The first possibility is observed for some A-type stars and is generally also applied to



BY Draconis stars. In this case the source of variation is sought in an analogue of sunspots, situated on the stellar surface. The second model is supported by theories that predict deformation for contracting stars that rotate very fast (see Lebovitz, 1974: *Astrophysical Journal* **190,** 121). In that case the observed intensity variations would be mainly due to temperature variations over the stellar surface.

By looking at the light-curves we can draw some general conclusions about the nature of the source of the variations. The smoothness of the light-curves and the absence of flat maxima and minima imply that the source itself is smooth and always present. The almost straight rising and descending slopes and the presence of always only one maximum and one minimum indicate that there is only one source for the variations. More sources would give rise to changing slopes and the occurrence of secondary minima or maxima. In addition, we observed that the amplitude of the light-curve can remain constant up to 1 per cent for over a year, some 500 to 1,500 revolutions. Therefore the source of the variations must be very stable. And finally, the observed relation between period and amplitude, as plotted in Fig. 2, indicates that there is a clear relation between the strength of the source and the rotational velocity of the star.

Explaining the observed variations by means of the spot-model will lead to the following unsatisfactory conclusions. There can be only one spot, of which parts must be visible at all times. This spot must be distributed smoothly over the stellar surface in such a way that it is more prominent on one side of the star. For an amplitude of 0.2 magnitudes (as in the case of Hz 1883) and the observed V-(V-B) relation we can calculate the surface covered by this "spot". It should cover 30 per cent more of the visible surface at minimum light than at maximum light. Because of the stability of the light-curve of Hz 1883 we conclude that the spot is not at all influenced by differential rotation. This is not in agreement with our knowledge of the sun with respect to sunspots and differential rotation on the surface. We therefore conclude that an explanation in terms of spots is very unsatisfactory.

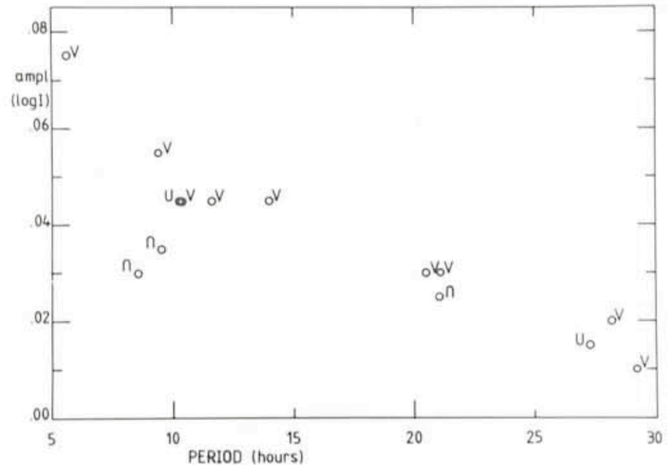


Fig. 2: *The period-amplitude relation for the Pleiades K-type stars.*

The other possible explanation, deformation, leads to a much simpler picture. The star could be deformed to a tri-axial ellipsoid due to its fast rotation, which would give rise to a smooth light-curve with two maxima and minima. The rotational periods of the stars would in that case be twice the photometric periods. The maximum radii of the stars would be around 1.5 solar radii but, as such a star is considerably flattened, this would not give rise to unacceptably high luminosities. When the period of the star decreases, the rotational velocity and hence the deformation will increase, which can be recognized in the light-curve, showing a larger amplitude, exactly as observed. Variability caused this way is much more stable than a large star spot, which can explain the stability of the light-curves. The differences in the shapes of the light-curves, the 'v', 'u' and 'n' shapes, could be due to different inclination angles, in which case the change in light-curve observed for Hz 686 and Hz 1124 would be the result of precession of the rotational axis.

The model of non-axial symmetry for fast rotating stars is not far enough developed yet to say whether it is a plausible explanation or not. However, as the theory developed by Lebovitz also predicts the formation for double stars it is very interesting to have a look at the angular momentum distribution over stars with different masses.

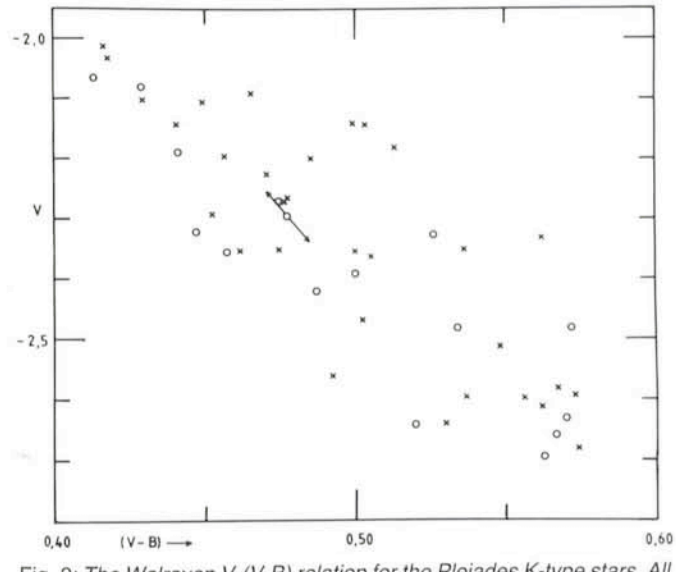


Fig. 3: *The Walraven V-(V-B) relation for the Pleiades K-type stars. All investigated stars are indicated by an open circle, others by crosses. For Hz 1883 the direction and size of its variations are also indicated by means of arrows.*

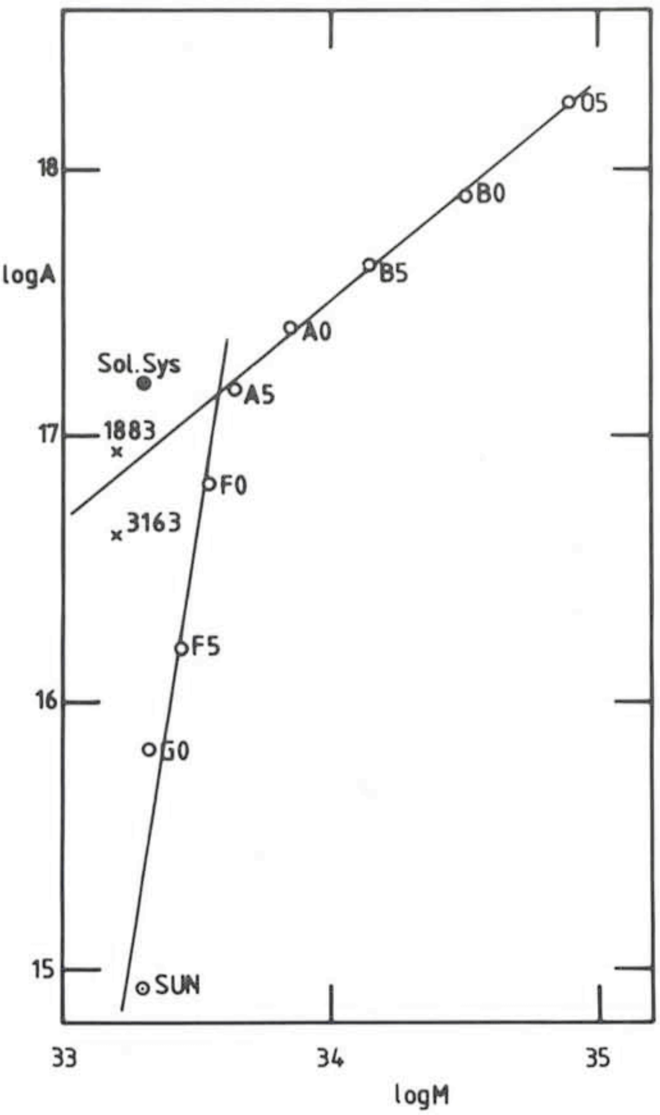


Fig. 4: *The relation between the angular momentum per unit mass (A) and the total mass (M) for average field stars, the solar system, the sun and two of the investigated K-type stars of the Pleiades.*

The Angular Momentum Distribution

In Fig. 4 we compare for average field stars their angular momentum per unit mass A and their mass M, following McNally (1964: *The Observatory* **85,** 166) who pointed out that there are two distinct relations with strongly different slopes, one for the O, B and A-type stars and one for the F and G-type stars. McNally also showed that the position of the solar system in this diagram seems to coincide with the O, B and A star relation while the sun itself follows the F, G star relation.

From this diagram McNally developed the following idea: The O, B and A stars are, because of their large masses, able to hold a high amount of angular momentum while the amount possible to hold for less massive stars rapidly decreases. The O, B and A star relation may therefore indicate the average amount of angular momentum present at the time of star formation. This would mean that the stars with a later spectral type than that of the turnoff point, at about spectral type A5, will not be able to hold all of their initial angular momentum and will somehow get rid of it. The fact that the solar system as a whole lies, in this diagram, very close to the O, B and A star relation suggests formation of planetary systems or double stars as mechanisms for losing excess angular momentum.

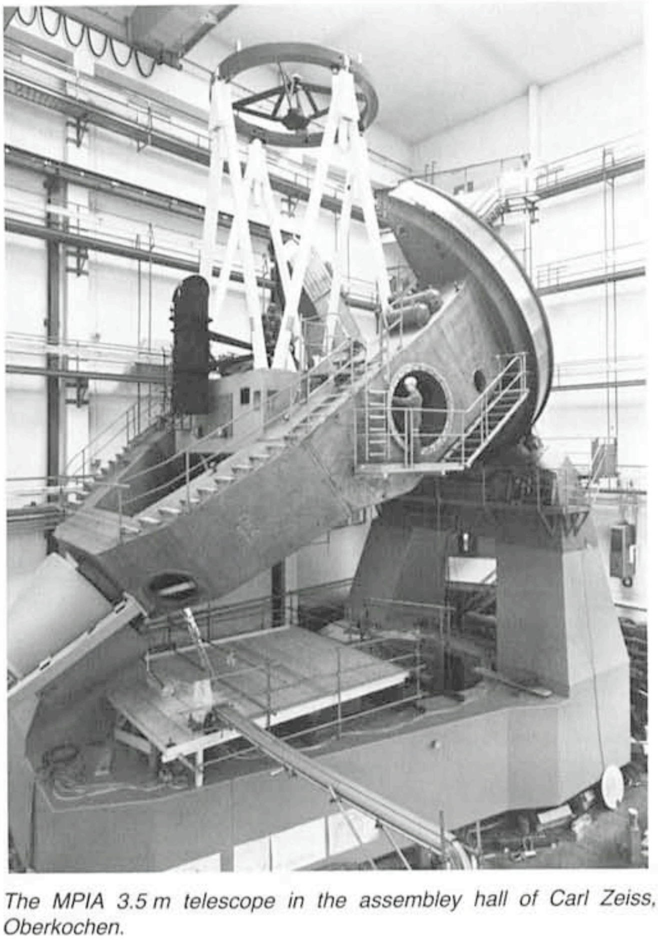
Looking at Fig. 4, we see that both Hz 1883 and 3163 follow the relation set by the O, B and A stars, which was assumed to be the initial distribution of angular momentum. This means that in this stage of the evolution, just before reaching the main sequence, the redistribution of angular momentum had not yet taken place. Our observations, together with the theory of deformation and breaking into two stars under fast rotation, may indicate that we observe this process for the K-type stars in the Pleiades.

We can conclude then that the redistribution takes place, for the K-type stars, on reaching the main sequence by forming double stars or possibly even planetary systems. These conclusions may also explain why so many field stars of the BY Dra type are known as close double stars. Finally, the disturbances as observed for the slower rotators like Hz 34 may be caused by material lost in the breaking-up process and which is still rotating close to the star.

A New Large Telescope for German Astronomers

On 9 March 1982 the largest telescope hitherto built in Germany was presented by Carl Zeiss to the public. It is the 3.5 m telescope of the Max-Planck Institute for Astronomy, which will be the center piece of the German-Spanish Observatory at Calar Alto in Southern Spain.

The 3.5 m telescope was built by Carl Zeiss in Oberkochen and its development and construction lasted about ten years.



The MPIA 3.5 m telescope in the assembley hall of Carl Zeiss, Oberkochen.

The instrument has a total height of 22 m and its weight is 430 tons. The primary mirror weighs 13 t and is made of glass ceramic Zerodur.

The instrument has meanwhile been dismounted and is being transported to Spain. The building has already been completed and it is expected that the instrument will become operational towards the end of 1983.

Optical Systems

Prime focus: focal length: 12.25 m; field diameter: with 2-lens corrector: 100 mm (28′), with 3-lens corrector: 243 mm (1°8′). *Ritchey-Chrétien focus:* focal length 35 m; field diameter 300 mm (30′). *Coudé focus:* focal length 122.5 m; field diameter 400 mm (11′). K. K.

Photographic Image Manipulation

Claus Madsen, ESO

Introduction

The Messenger No. 25 contained a short, general description of the non-atlas work being done in the Sky Atlas Laboratory. Briefly mentioned in the article were contrast manipulating methods ranging from masking—to reduce the contrast of a picture—to contrast enhancing methods used to obtain printable negatives (or positives). Here the procedure, the advantages and the problems connected with masking and image amplification, will be described in some detail.

Masking

Several ways of masking have been described during the recent years by Saxby and Dumoulin (1977), and Malin (1977). Yet, the subject does not seem to be exhausted. The masking method—which is capable of producing quite striking results with regard to extraction of information from high contrast plates—requires the application of a photographic mask (a reversed film copy of the original plate) of a somewhat lower contrast than the original.

At first, the masking film is exposed in contact with the original plate. Good results have been obtained by applying a diffuse light source and placing the masking film in contact with the *back* side of the original plate. Thus the mask becomes an unsharp, positive reproduction of the original photograph, the extent of unsharpness being determined by the thickness of the glass plate. After exposure the masking film is developed to a lower contrast (typically $\gamma \sim 0.6$) and then once again mounted to the original plate. The fact that the mask is unsharp makes superposition with the original plate less difficult, provided that the plate has been fitted with proper markings, and furthermore, the mask will not influence the finest details of the original. On the other hand, it tends to enhance the edges of the objects concerned.

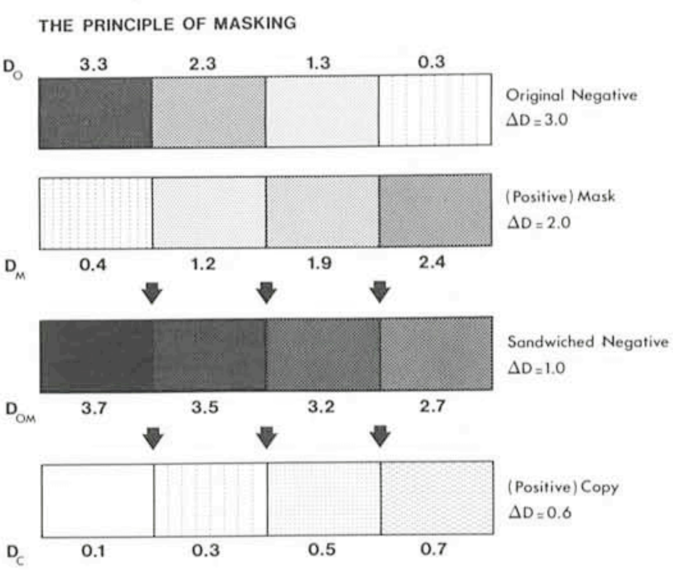


Fig. 1: *The principle of masking is illustrated by showing 4 densities in an original plate. The maximum density to be reproduced is 3.3, the minimum density 0.3. The non-linear response of the masking film is evident. The sandwiched negative plate/positive mask features a high overall density, but with a greatly reduced contrast.*

The sandwiched negative/positive is subsequently printed in a traditional way, either in a contact printer or by means of an enlarger, to get a positive film of a low contrast which still yields all the details of the original (Fig. 1). As almost any photographic emulsion the masking film has a non-linear response. In this case, however, this may be seen as an advantage, because accordingly, it does not exert its influence on the faint features of the original, thus securing a good reproduction of these, even if the density range as such is greatly decreased. It is to be noticed that the various (masking) film types will behave differently, thus having quite different effects on the final result, subject, of course, to the shape of their characteristic curves. Also the maximum density (D max) and the contrast of the mask is decisive with regard to its effect on the picture. Due to the fact that the developing has a vital influence on the density range of most emulsions, the characteristics of the mask are primarily controlled by the development, whereas the exposure plays a secondary role. (Apart from a few specialized emulsions, the effect of the exposure with regard to the contrast is secondary—but, by no means, unimportant—to that of the development.) Masked prints have appeared in the *Messenger* No. 25 (page 17) and in No. 26 (page 26).

Image Amplification

Perhaps of even more interest to many astronomers is the image amplification technique decribed by Malin (1981). The method which is used to enhance extremely faint objects on the original plates is based upon the fact that weak exposures are to be found in the uppermost layers of the photographic emulsion. Unfortunately, the density of a photographic film or plate is not exclusively determined by the exposure but also by the processing in which the development plays the most important—but by far not the only—role. The developer tends to react with the unexposed as well as the exposed silver halides, giving an overall density (fog). Furthermore, the carrier of the emulsion often has a density of its own. This is generally described as the base + fog density or the gross density. This "extra" density obscures the weakest images of faint stellar objects, leading to the apparent disappearance of these faint features in the overall density of the emulsion. In terms of photographic theory, these exposures are found in the area between the exposure threshold and 0.1 D above gross density (the "speed point", i.e. the point at which the speed of the emulsion is determined) on the characteristic curve of the emulsion in question. However, the silver halides which produce the fog are generally spread throughout the emulsion, which means that a separation between the weak exposures and the fog can be achieved by the printing method known as image amplification. As far as plates exposed to the sky background are concerned, it will often be found that the faintest objects are indeed not printable in traditional ways, because the density difference between the sky background and the faint object image is too small. The image amplification method, however, has proved equally efficient in this connection. By means of a diffuse lighting contact printer, a high contrast copy film is made. This printer, e.g. an Agfa-Gevaert SV-400, is the same as the one used for the masking. The diffuse light serves to suppress the base + fog density—insofar as this is caused by silver in the lower parts of the emulsion layers—without sacrificing the faint exposures in the top of the emulsion layer. These faint features thus become visible—and printable (Fig. 2). Of course, the method leads to a general enhancement of the grain in the upper layer of the emulsion and the contrast enhancement makes it difficult to distinguish

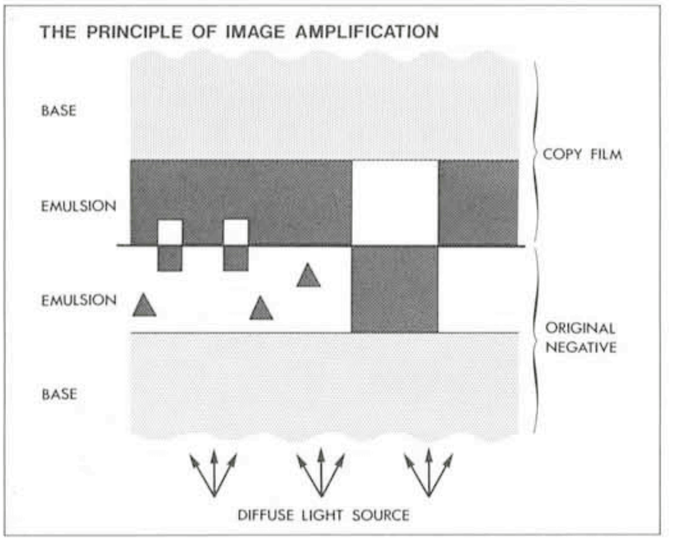


Fig. 2: *By using a diffuse light source, weak exposures (small squares) in the original plate are reproduced, whereas the fog (triangles) is reduced.*

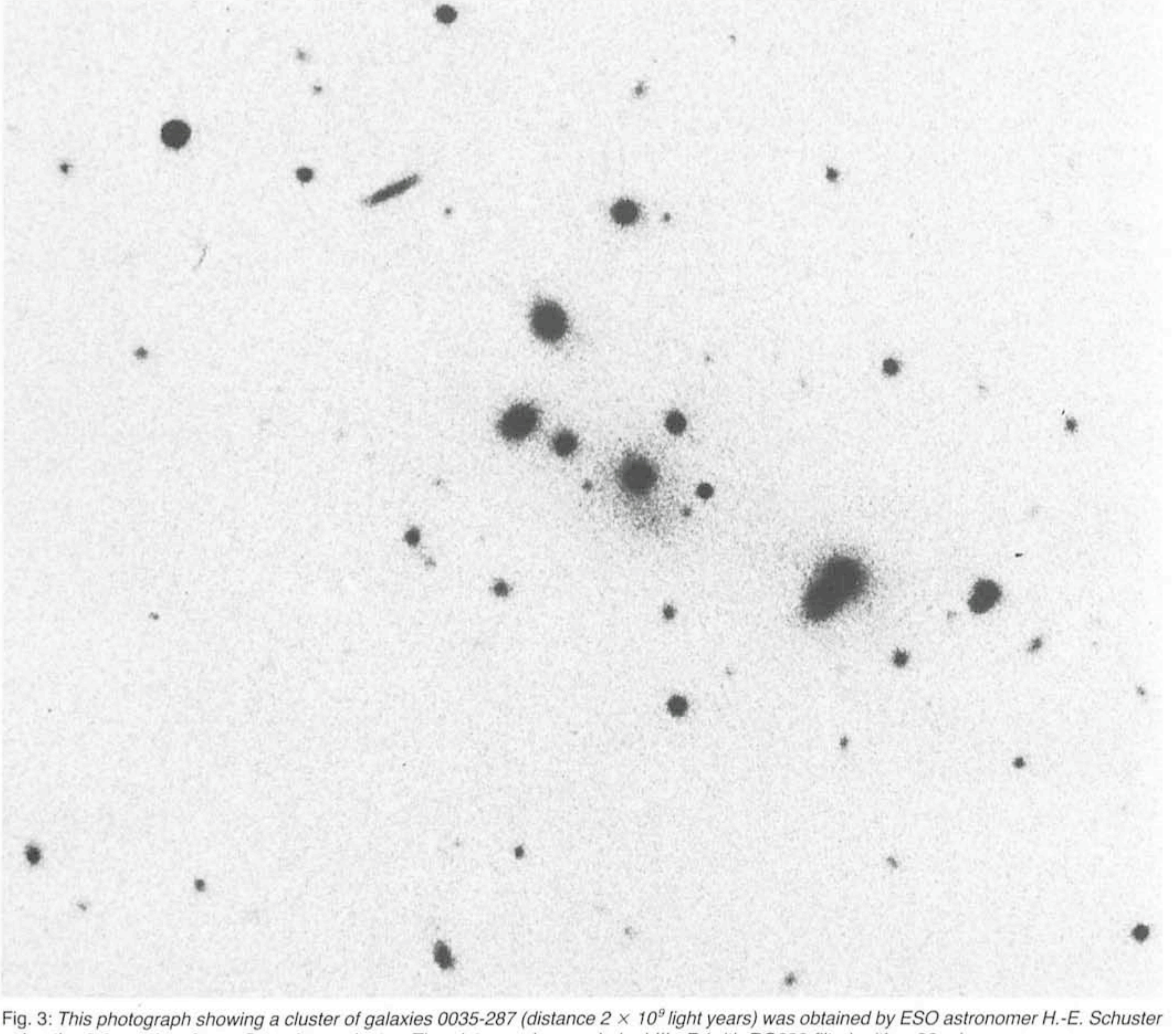


Fig. 3: *This photograph showing a cluster of galaxies 0035-287 (distance 2×10^9 light years) was obtained by ESO astronomer H.-E. Schuster using the 3.6-m prime-focus Gascoigne adapter. The plate used was a baked IIIa-F (with RG630 filter) with a 90 min. exposure.*

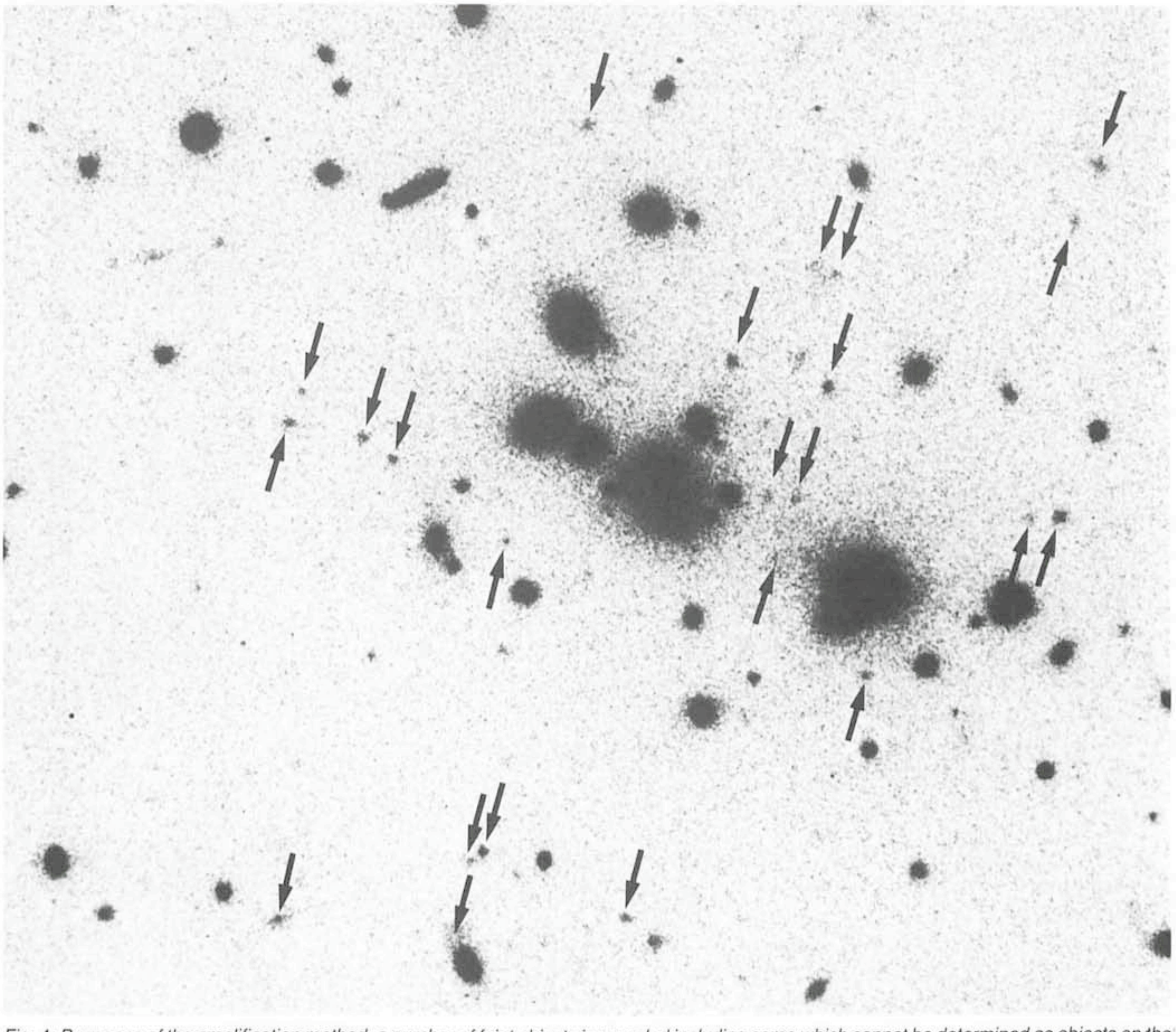


Fig. 4: *By means of the amplification method, a number of faint objects is revealed including some which cannot be determined as objects on the original plate. The tendency for the larger objects to "grow" is due to the limited exposure latitude of the high contrast copy film.*

density differences in brighter objects. Nevertheless, the method has proved to be quite effective when it comes to the reproduction of faint object images. An example of what can be achieved by this technique is shown in Fig. 3 and 4.

Conclusion

Masking as well as image amplification can be applied without big investments in sophisticated equipment. Without requiring unreasonable time, both methods still provide excellent opportunities to extract a maximum of information from the astronomical plates through individual treatment of each plate.

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ESO Workshop on "Ground-based Observations of Halley's Comet"

The ESO Workshop on "Ground-based Observations of Halley's Comet" took place at the Institut d'Astrophysique de Paris on 29 and 30 April 1982.

The aim of the workshop was to encourage cooperation between theoreticians and observers to get the best from all available observing facilities during the next apparition of comet Halley in 1985–1986 and especially of the optical telescopes on La Silla.

Comet Halley will indeed be best observable from the southern hemisphere and a large proportion of all telescopes in the south are concentrated at the ESO observatory in Chile.

The need for good astrometric measurements and accurate ephemerides for space probe navigation as well as for "blind" infrared, radio and radar observations were stressed. Ground-based observations necessary to complement the observations by the Japanese, USSR and European space probes have been discussed. Emphasis has been put on the need of a close cooperation between astronomers observing with different techniques to optimize the scientific output of these observations. Finally, a lively discussion showed that it was the general feeling that a close cooperation between the European astronomers and the NASA International Halley Watch would be beneficial for all.

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

The ESO/Uppsala Survey of the ESO (B) Atlas

by Andris Lauberts (ESO/Uppsala)

A systematic search for certain objects (NGC + IC galaxies, all galaxies with a diameter larger than about 1.0 arcmin, all disturbed galaxies, all star clusters in the Budapest Catalogue, and all listed planetary nebulae) has been carried out by means of the ESO(B) Atlas, covering the southern sky from –90 to –17.5 degrees. A total of 18,438 objects is listed; of these, about 60 % for the first time. Magnitudes and radial velocities are also given for a total of 2,102 galaxies.

Copies of the printed version are available for sale at the European Southern Observatory, Karl-Schwarzschild-Str. 2, D-8046 Garching bei München. The price of the volume is DM 40,–.

Copies of the magnetic tape version may be ordered from the Centre de Données Stellaires, 11, rue de l'Université, F-67000 Strasbourg.

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

KAZIMIERZAK, Bohumil (B), Mechanical Engineer, 1.3.1982
MACFARLANE, Penelope (GB), Scientific Reports Typist, 24.5.1982
TKANY, Sylvia (D), Receptionist, 1.6.1982
BRISTOW, Pamela (GB), Scientific Reports Typist, 1.7.1982

Departures

Europe

DOBROFSKY, Sonngard (D), Clerk-Typist (Telephone and telex operations), 30.6.1982
HEUBES, Hannelore (D), Clerk-Typist (Telephone and telex operations), 30.6.1982

Chile

LUB, Jan (NL), Astronomer, 31.5.1982
HESSENMÜLLER, Egon (D), Optical Technician, 30.6.1982

FELLOWS

Arrivals

Europe

MOUCHET, Martine (F), 1.6.1982

Chile

JENSEN, Kaare (DK), 1.7.1982

ASSOCIATES

Arrivals

Europe

LAUBERTS, Andris (S), 1.6.1982

Near Infrared Observations of O Stars

Y. Andrillat, Observatoire de Haute-Provence

Introduction

During the last two decades, one could note an increasing interest for the O stars because the far ultraviolet observations had an important impact on the study of these objects, displaying principally mass loss phenomena.

In the visible region, the spectrum of the O stars is characterized by the presence of absorption lines of H, and ionized He, C, N and Si. A few of these lines appear in emission in some stars, exhibiting the presence of an extended atmosphere around them. These emissions are due to:

- N III $\lambda\lambda$ 4634–4640 in the Of stars where other emissions can also be present, for example He II λ 4686 and C III λ 5696
- H lines in the Oe stars which are not exhibiting other emissions (no N III . . .).

The O stars have been observed in a very large spectral range from ultraviolet up to the red region. Photographic plates were used, but since their sensitivity is faint beyond λ 8750, they were exceptionally employed in the near infrared region.

As far as O stars are concerned, the published data available in the 1μ region are quite scarce. Although it is poor in features, the spectral interval $\lambda\lambda$ 8700–11000 is very important because it presents new helium lines, principally He I λ 10830 and He II λ 10123.

For O stars, helium is the fundamental element. The classification criteria are deduced from the value of the intensity ratio He I/He II.

Fig. 1 shows the spectrum of ζ Pup (O4f I(n)) obtained by M. Dennefeld at La Silla. It is characterized by a few faint lines: the hydrogen Paschen lines are visible in absorption from P7 to P15. Some emissions are present: He II λ 10123, N IV, N V and Hα. Several absorption bands are due to the earth atmosphere.

Observations

For approximatively twenty years, the development of modern detectors has allowed us to reach the near infrared region, but there are still few observational data in this region.

Since 1975, in collaboration with J.M. Vreux, we have studied O stars in the $\lambda\lambda$ 8000–11000 interval. We have used a

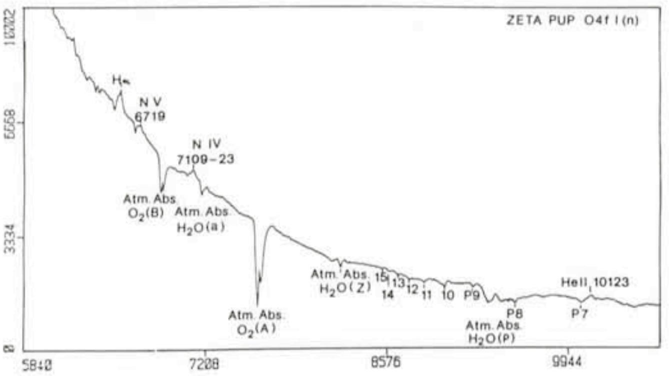

Fig. 1: *Spectrum of a typical Of star in the near infrared region (ESO 1.52 m telescope; Boller and Chivens spectrograph + Reticon; dispersion 228 Å mm^{-1}).*

cooled two-stage image-tube with a S1 photocathode attached to the grating spectrograph mounted at the Cassegrain focus of the Haute-Provence Observatory 1.93 m telescope. This spectrograph has its highest efficiency around 1μ to balance the sharp sensitivity drop-off of the receiver at wavelengths longer than λ 9500. The dispersion is small: 230 or 110 Å mm^{-1} and the covered spectral range is λλ 8000–12000.

However, the image-tube is not a very good receiver for the near IR study for it limits the investigation field because of several disadvantages: the biggest being the one inherent to the use of the photographic emulsions (sensitivity threshold, saturation, reciprocity law . . .). It is very difficult to obtain accurate photometric measurements (line intensities, equivalent widths, spectral distribution in the continuum).

In particular, it is not possible to take into account atmospheric absorptions and emissions which are present in the spectral range (Fig. 1): telluric absorptions of O_2 (A λ 7600 band – B λ 6870 band) and H_2O (Φ λ 11100 band – ρ λ 9420 band – γ λ 9060 band – Z λ 8227 band – a λ 7190 band).

These molecular bands are superimposed to the stellar spectrum and risk to mask important stellar features (absorptions or emissions). Moreover the OH night sky emissions are numerous and intense principally from λ 7500 up to λ 12000. They are variable during the night and they are dependent on the position of the star, the period of the year and also the situation of the observatory.

Thus, it was important to have a detector which permitted to solve all these problems. This is the reason why, among all the possibilities, Haute-Provence Observatory and ESO have chosen to put into operation a silicon detector (Reticon). It has a linear response allowing an accurate photometry (1 % approximatively). At the end of the exposure time, the spectrum can be examined immediately. Then it is possible to add or subtract several spectra and by this process to take into account the atmospheric absorptions and emissions.

Helium Lines

About ten years ago, J. M. Vreux and myself began a systematic study of O stars in the near infrared region (λλ 8000–11000), in particular the one of the helium and carbon lines.

Our first aim was to make, with an image tube, a quick qualitative survey of a large sample of O stars in order to prepare quantitative observations.

The observations of the helium lines are extremely useful for the understanding of helium formation in O stars and the corresponding data are requested for the study of the ionization balance of helium in theoretical models of stellar winds.

(1) The λ 10830 He I line ($2s^3S-2p^3P$) is particularly interesting because the upper level is a metastable one. In the visible region, another metastable transition, λ 3888.6, exists, but this line is blended with the hydrogen line: H_8λ 3888.0.

We have observed the He I λ 10830 line in 67 northern O stars, principally Of stars, in order to find the physical conditions which are requested to produce this line in emission (Y. Andrillat, J. M. Vreux 1979, *Astronomy and Astrophysics,* **76,** 221.

We have plotted the observed behaviour of λ 10830 as a function of spectral types and luminosity classes (Fig. 2):

- filled circles indicate that the emission is well visible,
- half filled circles: that it is uncertain or variable and has not been found on all the spectra of the star,
- empty circles: that it is absent.

The underlined circles indicate peculiarities in the spectrum.

From Fig. 2, it appears that an emission is observed at λ 10830 in 74 % of the O4–O8 supergiants but it is seen only in 29 % of the dwarfs, all the latter exhibiting some peculiarities in their spectra: for example, the presence of an envelope with rapid rotation, or the presence of a companion.

We have also searched for a possible correlation between the mass loss rate and the intensity of the λ 10830 emission.

The available data show a good correlation between the 2 parameters in O5–O9 stars: this effect is temperature dependent.

This result is in good agreement with the theoretical conclusions of L. H. Auer and D. Mihalas (1972, *Astrophysical Journal, Suppl.* **24,** 193) which predict the progressive appearance of the He I λ 10830 emission when the temperature is high (Te > 25000 K) and the gravity is low (log g ≤ 3).

However, it is important to note that in four very hot supergiants (O4f–O5f) there is no emission or the emission is uncertain.

Moreover, the problem of He I λ 10830 is associated to that of He I λ 5875. There is no agreement between the observations of the latter line and the theory, and it has been necessary to introduce a microturbulence effect to reduce the discrepancy, but the consequence is a marked increase of the λ 10830 absorption, which is not observed.

Finally, our observations indicate that the most favourable conditions to push He I λ 10830 in emission are that the envelope has a large amount of material and that the central star has a temperature between 30,000 and 45,000 K. These physical conditions are typically the ones used in the theoretical models (R. Klein, J. Castor 1978, *Astrophys. J.,* **220,** 902)

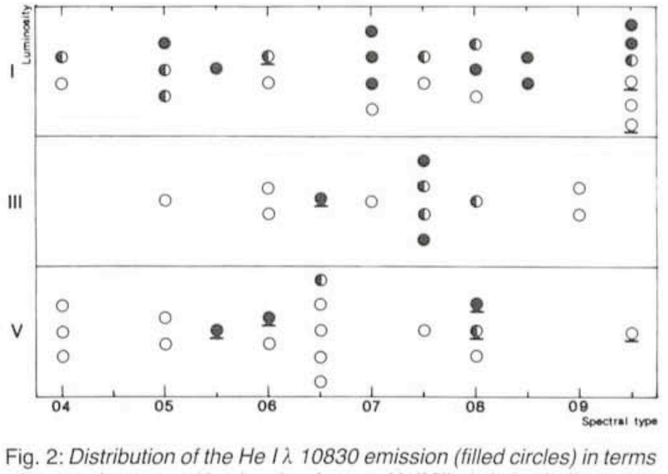

Fig. 2: *Distribution of the He I λ 10830 emission (filled circles) in terms of spectral types and luminosity classes. Half filled circles indicate that the emission is uncertain or variable and empty circles that it is absent. Underlined circles indicate peculiarities in the spectrum.*

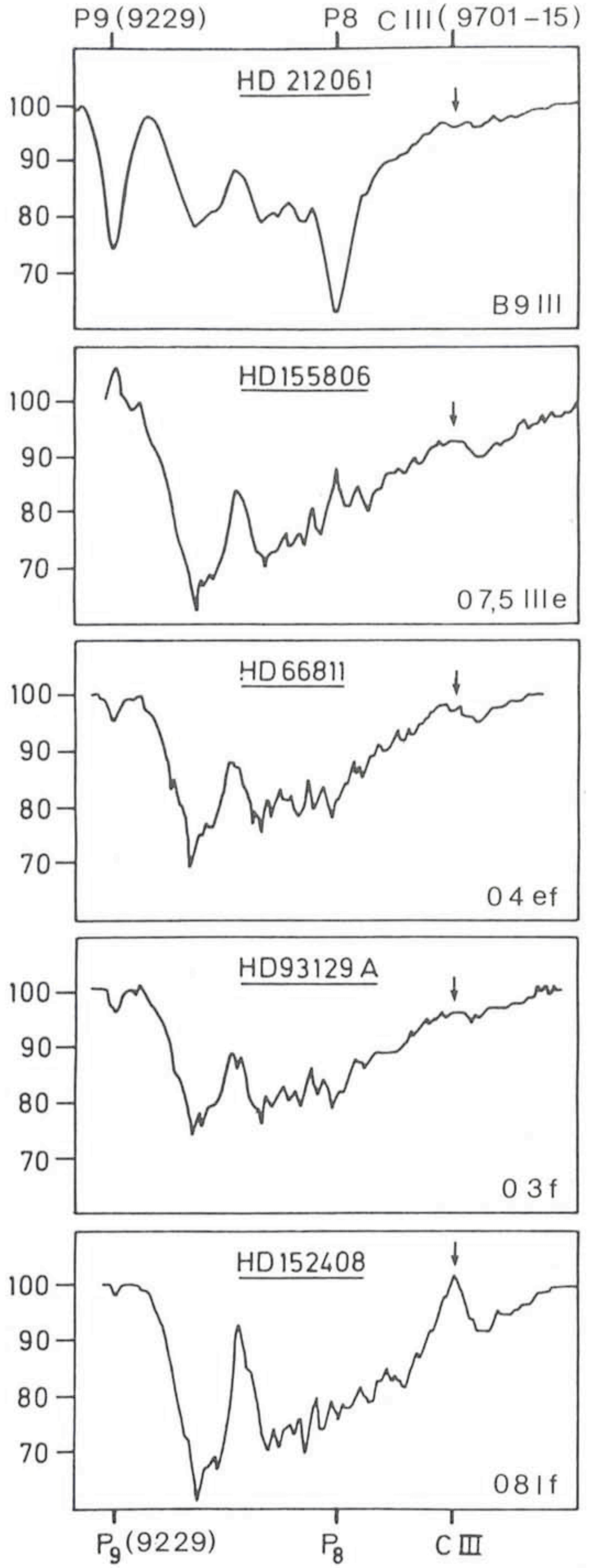

Fig. 3: *Spectra of 4 O stars around the C III λλ 9701–9715 lines. A B9 star spectrum given as comparison. All spectra corrected for instrumental sensitivity and referred to a normalized continuum. The arrows indicate the position of the C III lines.*

but we observe a higher intensity of the He I λ 10830 emission.

We have extended our observations to the southern O stars at the ESO Observatory, with the aim of clarifying the relation between the mass loss rate and the intensity of the He I λ 10830 line and, in the future, we plan to investigate the variability of this line which we have already observed in several stars.

The use of the ESO silicon detector (dual array RETICON) permits accurate intensity measurements. Owing to the linear response of this instrument, it is possible to take into account the atmospheric absorption H_2O λ 10832 and to subtract the OH λ 10828 night sky emission which are both superposed to the stellar line He I λ 10830.

Previously, our observations performed with an image tube had been limited to bright stars in order to have short exposure times and to prevent contamination of our spectra.

(2) He II λ 10123 line is the first member of the Pickering series (n = 4 ↔ n = 5). Observations of this transition are extremely important, in particular to decide which mechanism produces He II λ 4686 line (n = 3 ↔ n = 4): collision, de-excitation, pumping . . . It is interesting to know why the He II λ 4686 line is in emission in the spectra of some O stars while all the Pickering lines are in absorption.

According to the models of R. Klein and J. Castor, He II λ 10123 should be an intense emission in some O stars, stronger than the λ 4686 emission, the ratio of intensities λ 10123/λ 4686 ranging from 2.16 to 3.64.

Among thirteen O stars observed by D. Mihalas and G. W. Lockwood (1972, *Astrophys. J.,* **175,** 757), 2 stars exhibit λ 4686 emission and they are also the only ones with an emission at λ 10123, the value of the observed intensity ratio λ 10123/λ 4686 being about 1.3 (R. Klein, J. Castor).

Out of our large sample of O stars, we have observed emissions at λ 10123 in four other new Of stars and we confirm the small value of λ 10123/λ 4686 (J. M. Vreux, Y. Andrillat 1979, *Astron. Astrophys.,* **75,** 93).

Thus, it appears that the theoretical ratio is definitively too large. Unexpectedly strong λ 10123 absorption is observed in a few objects. This result raises again the question of pumping of the 2n–2n′ transitions of He II by the corresponding n–n′ lines of H.

It seems that, in some cases, a mechanism producing a similar effect takes place in O stars. If a pumping mechanism is not possible, D. Mihalas and G. W. Lockwood have suggested that the causes of the emission must involve chromospheric phenomena.

It is necessary to obtain good profiles of the He II λ 10123 and also a better determination of the intensity to decide which theoretical model is to be chosen. We have continued our observations in this sense and we have extended them to the southern hemisphere with the ESO Reticon.

The C III 9701–9715 Lines

It is very difficult to elaborate a theory concerning the mechanism responsible for the C III emissions in the O stars because very few observational data exist.

Indeed, there are only two C III emissions in the visible, λ 5696 and λ 4649, the two important other ones being situated in the near infrared: λ 8500, $3s^1S$–$3p^1P$ contaminated by P16 and λλ 9701–9715 contaminated by a strong water vapour atmospheric band (ϱ).

We have tried to observe the λλ 9701–9715 lines with an image tube but this is only possible when the lines are very intense (Y. Andrillat, J. M. Vreux, 1975, *Astron. Astrophys.* **41,** 133: detection in 3 Of stars).

The Reticon device is well adapted for these observations.

With this instrument, M. Dennefeld has obtained at the ESO 3.6 m telescope the spectra of 4 O stars (Fig. 3).

The corrections for atmospheric absorption have been achieved by standard photometric procedures (observations of a standard star at different heights above the horizon), but they are imperfect because these observations have been performed during the early phase of putting the instrument into service.

We do not detect any intense C III λλ 9701–9715 emissions in the 2 hot stars (O3 and O4) we have observed. These lines are also absent in the O7.5 IIIe star, but they appear as a strong emission only in HD 152408 (O8 If) which is one of the most "extreme" O stars with a very important extended envelope (Fig. 3).

Our results, deduced from a very limited sample (only four O stars) do not confirm the predictions of H. Nussbaumer (1971, *Astrophys. J.*, **170,** 93) that λλ 9701–9715 should be in emission in hot stars (T_{eff} = 40,000–50,000 K) without taking into consideration an extended atmosphere. On the contrary, our observations show that the presence of λλ 9701–9715 emissions depends essentially on the importance of the atmosphere, in better agreement with the theory recently developed by N. A. Sakhibullen, L. H. Auer and K. A. Van der Hucht who conclude that there is a temperature and a luminosity effect.

The Paschen Series Lines

P8 and P9 are very well visible on all our spectra: they are in absorption: strong in the classical B9 star which is normal, faint in the Of stars. These latter observations are compatible with the theoretical predictions. Klein and Castor have computed the contribution of the stellar envelope of O stars to the intensities of Paschen lines. In most cases, they obtain a strong emission contribution at Pα but a weak one at P6. If we extrapolate, it is normal to observe P8 and P9 in absorption.

Only the Oe star (HD 155806) exhibits P8 and P9 in emission but this star is related to Be stars which often present the Paschen series in emission.

Oe Stars

In the blue region, the spectra of Oe stars are similar to Be stars. So far, no Oe star has been observed up to 1,1 μ. It was interesting to fill this gap and to compare the spectra of Oe and Be stars in the near infrared (Y. Andrillat, J. M. Vreux, M. Dennefeld 1982, IAU Symp. No. 98 p. 229, Eds. M. Jaschek, A. G. Groth).

M. Dennefeld has observed HD 155806 (O 7.5 IIIe) with the Boller and Chivens spectrograph + Reticon at the ESO 3.6 m telescope in the spectral range λλ5900–11000.

The spectrum is very rich (Fig. 4) exhibiting many emissions: Hα is very strong and the Paschen series is visible up to P18. He I lines are present: λ 10830, not visible in Fig. 4, is intense; He II λ 10123 is absent; O I λλ 7772, 8446, Ca II infrared triplet, Fe II λλ 7515, 7712, 9997 are very well visible.

We have found all the elements identified in the Be stars. It appears that HD 155806 is related to Be stars of early type with

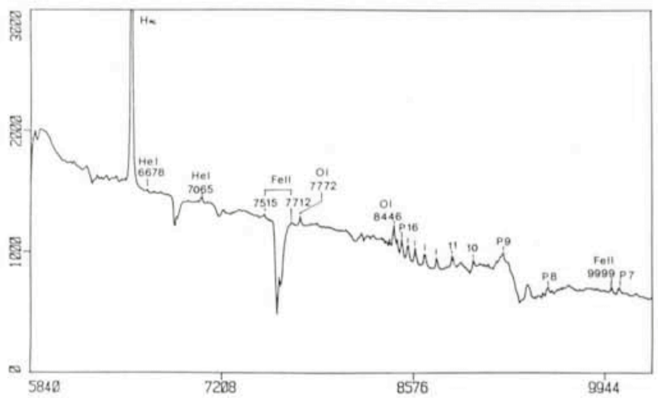

Fig. 4: *Spectrum of an Oe star in the near infrared: HD 155806 (O7.5 IIIe). (ESO 3.6 m telescope; Boller and Chivens spectrograph + Reticon; dispersion 228 Å mm⁻¹).*

a strong metallic envelope revealed by O I λ 7772 and Fe II λ 7712 both in emission and an Hα line very strong and without structure.

Moreover, a study concerning 68 Be stars (Y. Andrillat, L. Houziaux 1967, *Journal Obs.* **50,** 107 = Publ. OHP 9 n° 11) shows that the Paschen series and O I λ 8446 appear in emission in B0e, B1e, B2e . . . B5e stars but principally in B2e stars. He I λ 6678, visible in HD 155806, is present only in the B0e . . . B3e classes.

In conclusion, our observation confirms that HD 155806 initially classified as an O 7.5 IIIe is actually a Be star and very likely B2e or B3e star with strong metallic envelope.

Conclusion

In the evolutive scenario proposed by P.S. Conti, a link exists between the late-type O stars and the transition Wolf-Rayet stars. Some authors think that these WN7-WN8 stars have probably been formed from massive Of stars ($M > 35 M_\odot$), binary or not, having lost their mass by stellar wind effect.

It is therefore important to complete our knowledge of physical conditions in the atmospheres and evelopes of O stars. So it was desirable to extend the observations to a larger spectral range, in particular to the near infrared region for which observational data were very scarce.

This has been possible owing to the development of modern receivers, principally the ones with a linear response.

Our first observations in the near infrared have specified the behaviour of helium lines in terms of spectral types and luminosity classes in order to help the elaboration of theoretical models. In this spectral interval we have reached the important lines of C III and we could bring observational data to the studies of the processus of line formation. Finally the similitude between the Oe and Be stars are confirmed by their infrared spectrum. Especially the observations we have performed at the ESO Observatory using a Reticon receiver have already brought important results which are only a first approach of a further study of O stars which appears as a very promising one.

White Dwarfs—the Dying Stars

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Introduction

White dwarfs are one of the possible end products of stellar evolution—perhaps not as exciting as neutron stars or black holes, but certainly much more numerous: more than 90 % of all single stars end their life as a white dwarf.

A study of these objects can thus provide information on the mass budget of the galaxy as a whole as well as on the evolution of normal stars—e. g. the amount of mass given back to the interstellar medium during the stellar lifetime compared to that locked forever in the interior of the final remnant. Aside from these statistical considerations many white dwarfs are of great interest also individually. Some of them have large magnetic fields of the order of 10^8 G, some are members of X-ray emitting binary systems. The great advantage in the study of white dwarfs compared to neutron stars is that we are able to look directly at the surface and analyse the atmospheres with the methods of model atmospheres, determining effective temperatures, chemical abundances, masses, etc.

The current picture of stellar evolution towards the final stages for a star of solar mass is the following: On the asymptotic giant branch the star consists of a small, dense core of about 0.5 to 0.6 solar masses and a very extended envelope, where the nuclear energy generation takes place in two shell sources, burning hydrogen respectively helium. At the top of the giant branch the star somehow manages to get rid of its envelope, which after some time becomes visible as a planetary nebula with the former core of the giant as the exciting central star at effective temperatures of 50,000 to 100,000 K. About 20,000 years later the nebula is dispersed and invisible and the central star has now become a hot white dwarf. It has no possibility for further nuclear energy generation, the only available sources being gravitational and thermal energies. Under the physical conditions prevailing in white dwarfs the final evolution must be a cooling down at almost constant radius until the star becomes invisible after 5 to 10 billion years.

What are these physical conditions? White dwarfs are objects of the size of the earth with masses half that of the sun ($0.5\ M_\odot$); the density is around 10^6 g/cm^3. In the interior the atoms are completely ionized and the free electrons are compressed to such a small volume that according to the Pauli principle many are forced to have high momenta. The pressure of these "degenerate" electrons stabilizes the star against its own gravity—independent of temperature. Therefore nothing will happen to the white dwarf if it cools down to very low temperatures: it is really a final state!

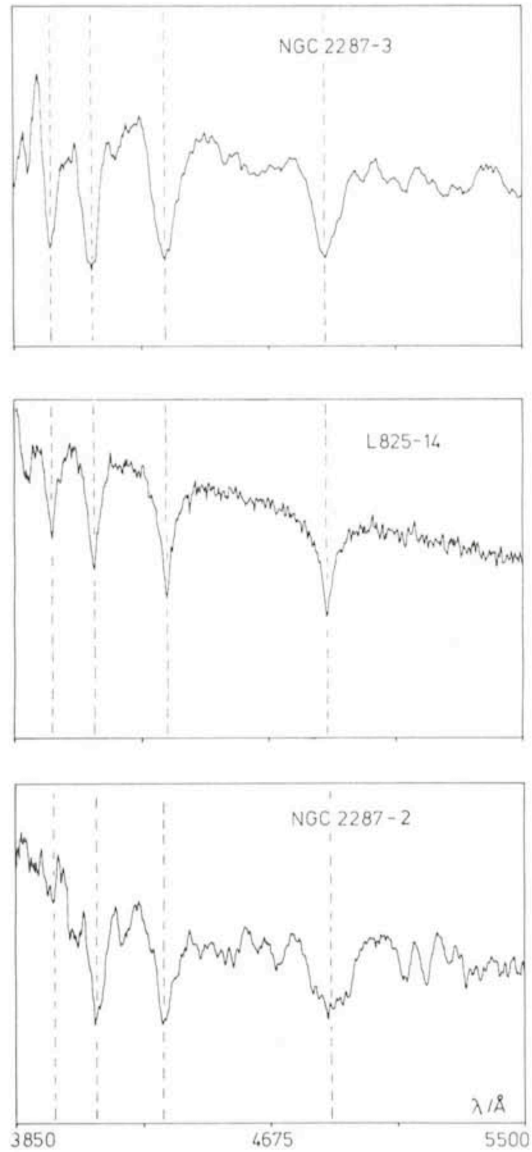

Fig. 1: *IDS spectra of white dwarfs No. 3 and No. 2 in the direction of NGC 2287. L825-14, a normal DA white dwarf in the field, is included for comparison.*

Which Stars Become White Dwarfs and which Not?

The largest mass for which stabilization by the degenerate electron pressure is possible is $1.4\ M_\odot$. However, also stars much more massive initially on the main sequence may loose enough mass during their evolution, especially in the giant phase, to get finally below this limit. Direct evidence is provided by the Hyades cluster with at least 6 white dwarf members. Since only main-sequence stars more massive than $2.1\ M_\odot$ (turnoff mass) can have evolved at all in the cluster lifetime, the parent masses of the white dwarfs must have been larger than this value.

At present we assume that it is only the initial mass, which decides about the final fate of the star, although this picture might be oversimplified (Weidemann 1980, IAU Coll. **59,** 339): stars with main-sequence masses below a critical value M_{wd} will become white dwarfs, those above M_{wd} supernovae and neutron stars (or black holes).

Several attempts have been made to determine the important parameter M_{wd}. Estimates from supernova statistics yield —with large uncertainties—$M_{wd} \gtrsim 5\ M_\odot$ (Tinsley 1975, *PASP* **87,** 837). Stellar evolution calculations including a semi-empirical mass-loss formula (Reimers 1975, *Mem. Roy. Sci. Liège* **8,** 369, Kudritzki and Reimers 1978, *Astron. Astrophys.* **70,** 227) also give $M_{wd} \approx 5\ M_\odot$ (Mengel 1976, *Astron. Astrophys.* **48,** 83; Fusi-Pecci and Renzini 1976, *Astron. Astrophys.* **46,** 417). Mass-loss rates have, however, not yet been determined for stars in the evolutionary phases near the top of the second giant branch most relevant for the total amount of mass loss.

Thus the only safe method to determine M_{wd} seems to be the identification of white dwarfs as members of galactic clusters in which stars around or slightly below M_{wd} are dying at the present time. The Hyades cluster is not particularly suited, since the turnoff mass is only about $2.1\ M_\odot$. Up to now, the only conclusive case seemed to be LB1497, a Pleiades member, with a progenitor mass $\gtrsim 6\ M_\odot$.

In order to improve the statistics Romanishin and Angel (1980, *Ap. J.* **235,** 992 = RA) conducted a search for a statistical excess of faint blue objects in galactic clusters compared to a nearby comparison field. They used a photographic method and confined the search to clusters in the galactic plane, where the blue extragalactic objects expected at faint magnitudes are obscured by the galactic dust layer. They found indeed several white dwarf candidates and, applying some statistics, concluded that $M_{wd} \approx 7\ M_\odot$.

Observations at La Silla

The main disadvantage of RA's method is that the identification of white dwarfs and cluster membership rests solely on blue colour and statistical considerations. I therefore decided—in collaboration with D. Reimers (Hamburg)—as a first step to continue the programme of RA with an attempt to make spectroscopic observations of the candidates identified by RA in the clusters NGC 2287 and NGC 2422 (Koester and Reimers 1981, *Astron. Astrophys.* **99**, L8). White dwarfs in these clusters are expected at magnitudes between $19^{\rm m}.0$ and $21^{\rm m}.0$, which means that a large telescope like the ESO 3.6 m is certainly required. The Image Dissector Scanner (IDS) is an ideal instrument for this kind of work, since it allows the subtraction of the sky background (much larger than the stellar signal!) and because high resolution is not necessary: most white dwarfs show only the Balmer lines of hydrogen broadened to $\approx$ 50 Å width by the high pressure in the atmospheres. These lines are easily identified even at a resolution of 10 Å.

For an observer not accustomed to such faint magnitudes it takes time to get used to some problems and the help of the staff astronomer and night assistant was gratefully accepted. The stars are so faint on the field of the television screen that integration times of the order of one minute are required to make them visible. If a brighter star is nearby its image may get so large that it completely hides the white dwarf. Also the guiding demands some skill if it takes a minute to see the result of the operation! When the object is finally in the aperture, the excitement is of course large, if after 10 min integration time—as was the case with exceptionally good seeing—the Balmer lines can already be seen in the raw spectrum, confirming that the object is indeed a white dwarf!

Fig. 1 shows two of the objects observed in the direction of NGC 2287 after 4 hours integration time. These are clearly white dwarfs of spectral type DA, as documented by the broad lines and a comparison with the field DA L825-14.

However, besides this information, what can the spectra tell us about cluster membership?

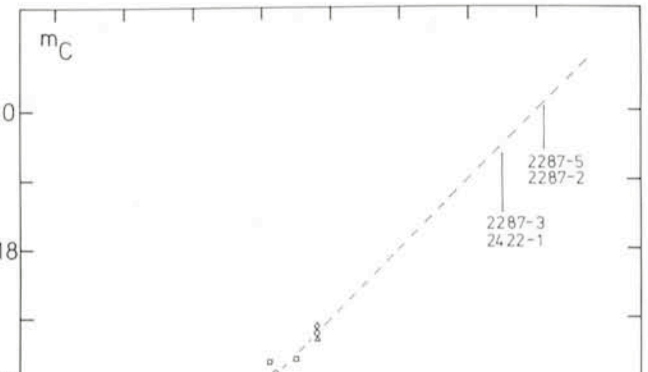

Fig. 2: *Calibration of visual magnitudes derived from IDS count-rates (m_c) versus m_v for known field white dwarfs. Different symbols distinguish observations of different nights; vertical lines mark the positions of the cluster candidates.*

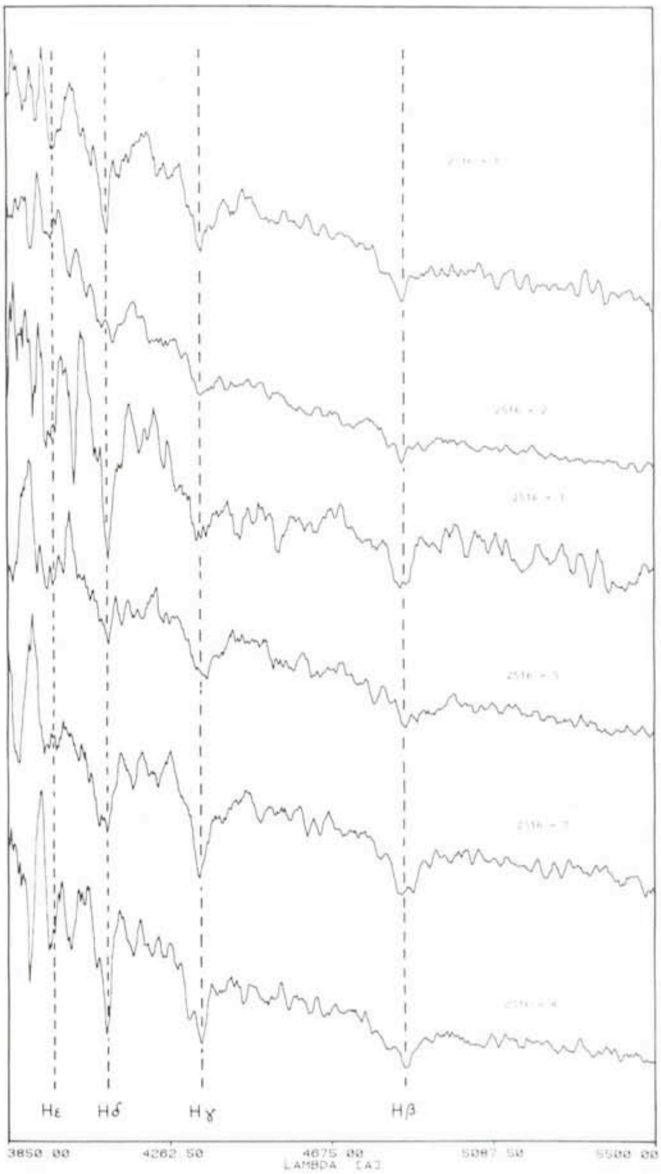

Fig. 3: *Six DA white dwarfs in the direction of NGC 2516. Nos. 1, 2, and 3 are close to the cluster centre.*

From the comparison of line equivalent widths with theoretical calculations a rough estimate of effective temperature is possible, which together with the fact that the DA seem to be confined to a narrow range of radii (Koester, Schulz, Weidemann 1979, *Astron. Astrophys.* **76,** 262) leads to an absolute magnitude for the objects. With the known distance modulus ($9^{\rm m}.4$) for NGC 2287 the expected V magnitudes are $21^{\rm m}.1$ for No. 3 (with an admissible range, including all uncertainties, of 20.1-23.2) and $19^{\rm m}.9$ (range 18.9-22.0) for No. 2. Unfortunately the V magnitude is not known and would be difficult to obtain photometrically. To overcome this problem we made an effort to use the IDS itself as a photometer. The wavelength region used (4000-6000 Å) roughly covers that of the Johnson V band. We therefore just added all net counts (sky subtracted) of the IDS system, derived a magnitude from this number (≈ -2.5 log N) and calibrated this against the known V magnitudes of brighter DA white dwarfs observed during the same nights at similar zenith distance. The scatter around a linear relation with slope 1 turns out to be surprisingly small and gives us confidence in an extrapolation to V $\approx$ 20 (Fig. 2) which, however, relies heavily on the assumed linearity of the IDS at low count-rates. The derived magnitudes are 19.5 ± 0.5 (No. 3), respectively 20.1 ± 0.5 (No. 2). A comparision of this observed V with the expected value, together with a thorough discussion of error margins, cooling ages of the white dwarfs, and cluster ages led us to the conclusion that 2 of the 3 white dwarfs identified in the direction of NGC 2287 (including No. 2) are most probably cluster members, whereas No. 3 is probably a foreground object. From the turnoff mass of NGC 2287 we thus find that M_{wd} is definitely larger than 3.9 $M_\odot$.

The next step in our project was the extension of RA's photographic search to clusters accessible only from the southern hemisphere. H. E. Schuster (ESO) took excellent Schmidt plates of several clusters in the red and blue spectral regions, which allowed us to find many blue candidates. For NGC 2516 the spectroscopic observations have been completed by D. Reimers in March 1982. Fig. 3 shows 6 white dwarfs identified, three of which lie very close to the cluster centre. An analysis like that for NGC 2287 has not yet been completed; we are quite sure, however, that at least some of them are cluster members. This will bring the lower limit on M_{wd} up to 5 $M_\odot$, without using any statistical considerations.

Conclusions

The 3.6 m ESO telescope and the IDS are an ideal combination to identify extremely faint white dwarfs in open clusters. We have now set by purely observational methods the lower limit of the critical mass M_{wd} that determines the final fate of single stars (white dwarf vs. supernova) at ≈ 5 $M_\odot$. In the case of NGC 2516 one of the original candidates turned out to be probably a QSO. The extragalactic background is obviously not completely obscured even at low galactic latitudes, and spectroscopic observations are necessary to distinguish white dwarfs.

In the future we plan to extend our search to clusters with even higher turnoff masses, and a number of candidates have already been detected on the Schmidt plates.

High Spectral Resolution Observations of [S II] Lines in the Planetary Nebula IC 418 at the CES Spectrograph

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Summary

Preliminary observations of [S II] lines at 6717 and 6731 Å of the planetary nebula IC 418 are presented. Observations are made with the ESO Coudé Echelle Spectrometer (CES) and the Coudé Auxiliary Telescope (CAT); the resolving power is 10^5, corresponding to a dispersion of 1.87 Å mm^{-1} or a spectral resolution of 0.067 Å. Both [S II] lines present two well separated components corresponding to a shell expanding at the velocity of 30.3 km s^{-1}. It is shown that density and thickness of this shell, as observed on the line of sight at two diametrically opposite points, are similar, whereas the S^+ concentration suggests a non-symmetrical ionization structure.

Introduction

The low-excitation planetary nebula IC 418 is a small, nearly round (14 × 11″) ring-shaped nebula. Because of its apparently simple structure it has been carefully studied both observationally and theoretically. Wilson and Aller (1951), Aller (1956) and Reay and Worswick (1979) have published isophotes for several emission lines. Osterbrock (1970) has made high resolution spectral observations at the coudé spectrograph of the 100 inch Mount Wilson telescope: the dispersion was 4.1 Å mm^{-1} in the green spectral region and 6.5 Å mm^{-1} in the red. Whereas the [N II] lines showed double, the [O III] and hydrogen line profiles showed no central dips, in good agreement with Wilson's pioneering work (1950, 1953). This is explained by the fact that O^{++} ions are concentrated near the centre of the nebula, where the expansion is lower, while N^+ is present in the outer layers where the expansion is larger. Simple hydrogen line profiles can be explained partly by the fact that thermal Doppler width is larger and also by the fact that these lines are formed throughout the nebula.

High resolution spectrographic observations of the [S II] doublet at 6717–6731 Å allow the measurement of the expansion velocity of the nebular shell and the determination of the density of this shell (Pradhan, 1978; Cantó et al., 1980; Czyzak and Aller, 1979). On the other hand, from previous observations, it is expected that low-excitation lines, such as the [S II] doublet, will present the most evident splitting effect. These are the reasons why we decided to observe IC 418 at these wavelengths in order to check the feasibility of spectrographic observations of (southern) planetary nebulae with a resolving power of 10^5 with the CES at the coudé focus of the 1.4 m CAT. This first test is quite promising.

The Observations

The integrated magnitude of this planetary nebula is given as 12; we used a slit of 1.3 × 5 arcsec which corresponds, at face value, to a magnitude of nearly 15. The slit was kept aside the central star (m ~ 10.5). Observing conditions (seeing, transparency) were good. The detector was the presently used Reticon Chip cooled to 136°K, the central wavelength 6723 Å and the spectrum length 52 Å. The resolving power was 10^5, corresponding to a spectral resolution of 0.067 Å or a linear dispersion of 1.87 Å mm^{-1}, the channel width being 0.028 Å. The

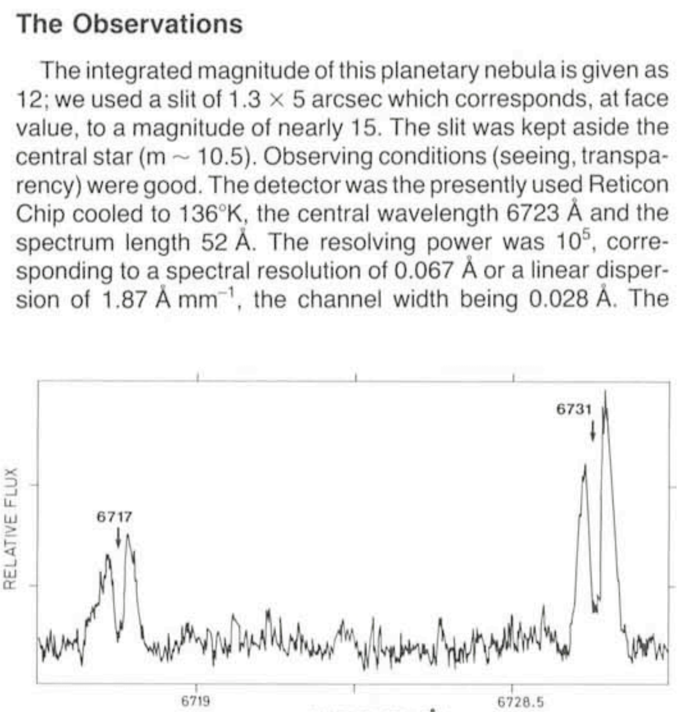

Fig. 1: *Spectrum of IC 418 showing the [S II] emission lines. This spectrum was obtained on 7 December 1981; the exposure time was 5400 s.*

integration time was 1^h30^m. The signal-to-noise ratio, for the continuum is of the order of 20 corresponding to an effective magnitude of the order of 8.5 (see for instance the S/N ratio values as a function of the V magnitude given by D. Enard (1981) essentially due to the emission lines).

The spectrum is shown in Fig. 1. Profiles of both [S II] lines at 6717 and 6731 Å appear double; the separation of the two peaks corresponds to an expansion velocity of the shell of 30.3 km s^{-1}. This value is in good agreement with the result obtained from [N II] line observation by Osterbrock (1970).

Let us call I_{1B} and I_{1R} the blue and red shifted components of the [S II] line at λ = 6717 Å, I_{2B} and I_{2R} the corresponding components of the [S II] line at λ = 6731 Å. A cursory examination of the line profiles permits the following comments:

(1) The ratios $I_{1B}/I_{2B} = 0.58$ and $I_{1R}/I_{2R} = 0.56$ show that both recessing and approaching parts of the expanding shell have similar electron density.

(2) The widths at half-maximum of I_{2B} and I_{2R} have the same order of magnitude ($\Delta\lambda \sim 0.45$ Å); therefore, it may be expected that the corresponding parts of the expanding shell have similar thickness.

(3) The ratios $I_{1B}/I_{1R} = 0.84$ and $I_{2B}/I_{2R} = 0.80$ are also quite similar. Taking into account the previous comments, this indicates that the abundance ratio of S^+ ions in the recessing (R) and approaching (B) parts of the expanding shell is of the order of 0.8. This may be due to a non-symmetrical ionization structure of the nebula as suggested by Osterbrock (1970) from other considerations.

Conclusion

So far, it is the first time that the planetary nebula IC 418 is observed with a spectral resolving power as high as 10^5. Both [S II] lines at 6717 and 6731 Å show well separated components corresponding to a "classical" expanding shell. Density and thickness of both parts of the nebula observed on the central line-of-sight are quite similar. However, the S^+ concentration seems larger in the farther (recessing) part of the shell than in the nearer (approaching) part. This is certainly due to a non-symmetrical ionization structure of the shell.

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The Fate of Dust Grains in a Shock Wave Originated by a SN Explosion

S. D'Odorico and A. F. M. Moorwood, ESO

Observations of SNR at 10 μm can be compared with the theoretical prediction of IR emission of shock-heated dust.

1. The Role of Dust in Supernova Remnants

Several theoreticians have investigated the behaviour of dust grains in the surroundings of a supernova explosion. It has been suggested by the computations (Silk and Burke, 1974, *Astrophysical Journal* **190,** 11) that thermal energy from the gas heated by the passage of the SN blast wave should be deposited in the dust grains by ion-grain and electron-grain collisions and subsequently radiated by the dust in the infrared. The efficiency of this cooling mechanism depends mainly on the interstellar medium pre-shock density and the shock velocity. Other important parameters are the assumed composition and size distribution of the grains and the rate of collisional heating and destruction for the grains in a hot plasma.

The more recent computations have dealt with a variety of physical cases. Shull (1980, *Ap. J.* **237,** 769) and Wheeler et al. (1980, *Ap. J.* **237,** 781) studied the emission of dust for the case of a SN exploding in the vicinity of a dense molecular cloud. In this case the main heating mechanism for the grains is absorption of UV and X-ray photons from the hot interior of the SNR, and the larger fraction of the infrared emission comes from the grains exterior to the shock. According to the theoretical computations, this type of remnants could be discovered in a survey of nearby galaxies at infrared and X-ray wavelengths but it is unlikely that it can be detected in the optical because of the heavy extinction in the dense material which surrounds the SN.

Draine (1981, *Ap. J.* **245,** 880) and Dwek (1981, *Ap. J.* **247,** 614) concentrated on the infrared fluxes expected from the dust heated by collisions in the hot interior of a SNR. This dust, originally associated with the interstellar gas, is only partially destroyed by the passage of the shock wave. Dwek and Werner (1981, *Ap. J.* **248,** 138) considered the emission from grains formed in the SN itself, which are to be found in the fast moving ejecta observed in the remnant or in the "evaporated" gas which surround them.

However detailed the calculations, there is as yet no direct observational evidence for the presence of grains in a SNR. For this reason, any observational results, being it a detection or a significant upper limit, is useful to understand the fate of dust in a SN vicinity. So far a systematic search for infrared emission (80–350 μm) has been made only in three young galactic SNR (Wright et al., 1980, *Ap. J.* **240,** L157).

Preliminary Results for the 10 μm Emission from SNR in the LMC

Systematic observations of three remnants in the LMC were carried on one night last November at 10 and 12 μm, using the ESO bolometer attached to the 3.6-m telescope with a diaphragm of 7.5 arcsec diameter (see the article by Moorwood in this issue for details on the instrument).

The choice of our targets in the Large Magellanic Clouds has various motivations. For a given diaphragm, the fraction of a remnant surface seen at the distance of the LMC is much larger than for a galactic case thus making a systematic exploration much easier. On the other hand, if the dust is distributed

Fig. 1: *The positions of the 10 and 12 μm observations in the supernova remnant N63A and the adjacent H II region are indicated with crosses on this sketch from an Hα photograph by B. Lasker. The circle shows the size of the observing diaphragm. The probable detection was obtained in the south-east knot of the SNR.*

homogeneously the surface brightness is distance-independent. Finally, the specific properties of the three LMC remnants, N49, N63A and N132D, appear more favourable to the infrared emission than those of most galactic remnants in the southern hemisphere. They are the three brightest X-ray SNR in the LMC and among the brightest X-ray sources on an absolute scale in that galaxy. They have been observed with the Einstein Observatory High Resolution Imaging instrument (HRI) and the Solid State Spectrometer (SSS). When these results will become available we will know both the distribution and temperature of the hot plasma. As for the optical observations, it was already known from the work of, e.g., Dopita (1979, *Ap. J. Suppl.* **40,** 455) that the expansion velocity of the optical filaments is between 100 and 200 km/sec. In N132D, fast moving (v ~ 4,000 km/sec) knots of emitted materials are also observed. It has been suggested that some of these condensates represent processed material from the supernova explosion, where dust formation would be enhanced.

We observed three positions in N132D and N63A and two positions in N49. At one position in N63A (see Fig. 1) a flux of 130 mJy was measured at a 2.6 σ level. At all other positions no detection was obtained at a 2 σ level (50–80 mJy).

Since the properties of the dust are not defined univocally, we need to know with reasonable accuracy at least the temperature and density of the gas which heats it, to interpret the results. A detailed comparison of theory and IR observations must then wait for the publication of the Einstein Observatory results. However, by using the preliminary estimates which are available and, e.g., the theoretical formulation by Dwek and Werner (1981, *Ap. J.* **248,** 138) it is already possible to estimate the significance of our data. By assuming log T = 6.8 and n_e = 5 for the hot gas we derive a grain temperature between 80 and 300 °K depending on the type and size of the grains. At the distance of the LMC, 130 mJy then imply 6.5 $M_\odot$ of dust in the first case, 6×10^{-3} $M_\odot$ in the second. The first appears a much too large value to be acceptable.

The upper limits are also significant. For the higher grain temperature, 50 mJy imply a mass of dust of less than 2×10^{-3} $M_\odot$, and a gas to dust ratio larger than 10^3.

We stress again that these values are only indicative and an estimate of the total mass of dust and of its properties is premature. An additional uncertainty is in the geometrical correction to apply to a partial observation to get the integrated flux. It was pointed out in the preliminary discussion of Long, Helfand and Grabelsky (1981, *Ap. J.* **248,** 925) that the X-ray diameters of the LMC supernova remnants are significantly larger than the optical ones. If heated dust is present wherever hot gas is observed, the total infrared flux may be larger than expected.

From the point of view of the infrared observations, we hope in the near future to confirm the detection at 10 μm and extend the survey to the regions which do not emit optically but are visible in the X-ray maps. Under optimum observing conditions it should be possible to lower the σ level by at least a factor of two and thus placing even more stringent limits on the dust content. It would be also quite useful to complement these results with observations at longer wavelengths with a future space-operated facility to detect or rule out the presence of a significant amount of dust at lower temperature.

If the dust behaves like the theoreticians think it should, the infrared observations of SNR seem indeed a useful way to investigate its presence and its properties.

A Long Period Eclipsing Binary Project – Five Years of Observations at ESO

P. Ahlin and A. Sundman, Stockholms Observatorium

The star HD 161387 first caught our eyes when we were reading an article on ζ Aurigae stars by K. O. Wright in *Vistas in Astronomy* No. 12. This was some 8 or 9 years ago.

ζ Aurigae stars are eclipsing binaries formed by a cool supergiant K star and a very much smaller and hotter main-sequence (more or less normal) B star. Out of eclipse the B star dominates the blue spectral region, but a pure K-type spectrum is found in eclipse. The drastic spectral changes for HD 161387 can be seen in Fig 1c and 1d. Periods for these binaries are in the range of 2 to 10 years. The general benefit of ζ Aurigae star studies is the possibility of direct determination of physical parameters of the components such as masses and radii. In practice, what one does observe is the change in radial velocity of the stars as they orbit around their common centre of gravity and the change in magnitude as the light from the B star is eclipsed by the K supergiant. There is also the possibility of studying the structure of the atmosphere of a K supergiant manifested by spectral changes occurring as the point light of the B star shines through the outer parts of the K star close to the total eclipse. Besides ζ Aurigae itself only the stars 31 and 32 Cygni have been studied in greater detail.

Looking through the literature we found that not very much

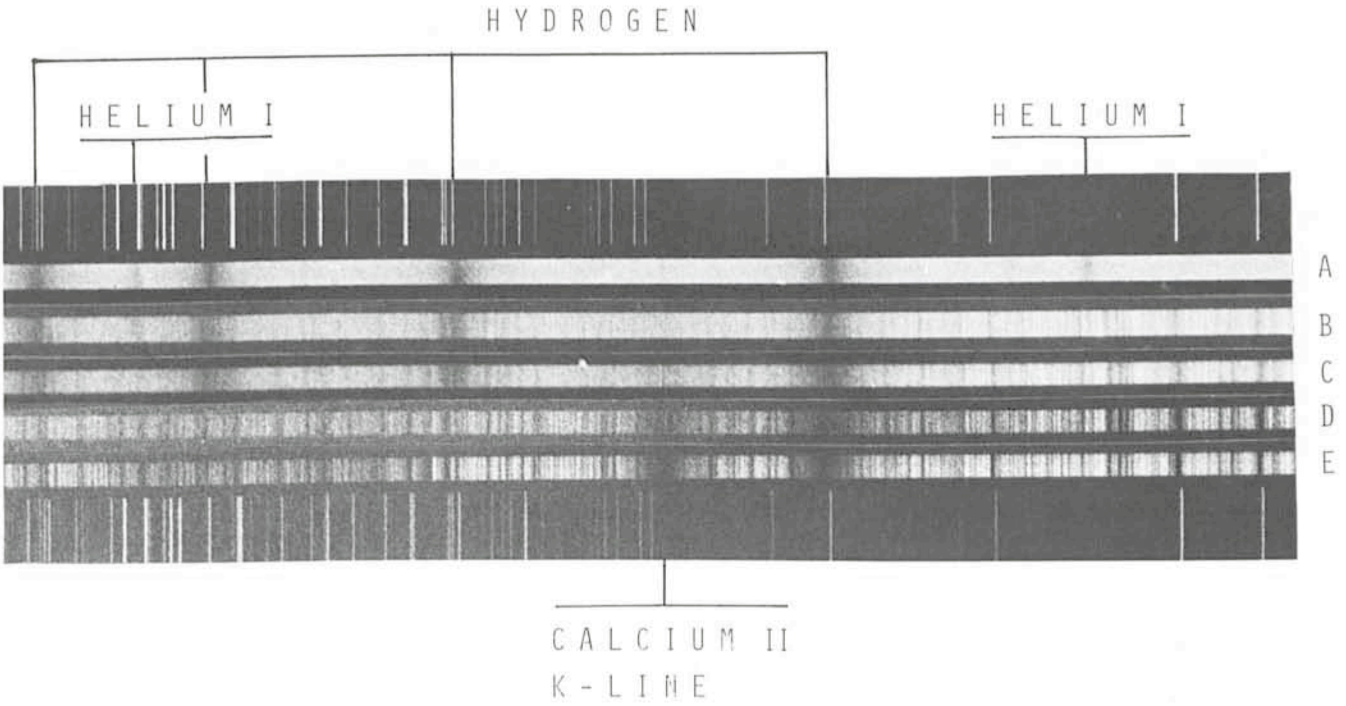


Fig. 1: *A: The B star ϱ Aurigae.*
B: The K + B star ζ Aurigae out of eclipse.
C: The K + B star HD 161387 out of eclipse.
D: The K + B star HD 161387 in eclipse, only the K star spectrum is visible.
E: The K star β Apodis.
The spectra A and B were obtained at the Observatoire de Haute-Provence, the spectra C, D and E at ESO. Original dispersion: 20 Å/mm.

had been done on HD 161387 by others lately. There was of course a fundamental paper in the *Harvard Bulletin* 914 by Swope in 1940 (when neither of us was yet born) giving the mean light-curve, period (936 days) and duration of the eclipse (56 days). There was also a spectral classification (K5 Ib + A) made by Popper in 1948, and a warm invitation by Fracastoro in 1956 to all observers of the southern hemisphere to observe this star. A HD 161387 project could therefore certainly be motivated scientifically:

1. Few similar objects had been investigated before.
2. More basic data of great astrophysical importance could be expected.
3. The techniques of observations and reductions were all well established, easily understood and inexpensive.
4. The thorough investigation by Swope gave a solid foundation for further research.
5. A HD 161387 project had been recommended in the literature.

In Stockholm, at latitude 59° north, HD 161387 at best reaches 5° above the horizon close to our midsummer twilit midnight. Was this a star for us to observe?

There were some other major objections to embarking on a project on HD 161387 that first had to be thoroughly looked over.

The first one was time. The period of the star is around 2.5 years and to get an acceptable coverage of all phases of the period it is necessary to observe it for at least 5 years. This should be compared to the ideal thesis-making time of 4–5 years. To the devoted ones, such an objection is however immorally pragmatic. Besides, one of us (Sundman) already had her Ph. D.

Secondly, the frontier of binary science long since swept over the long-period binaries and the general interest is now focusing on short-period contact phenomena. This objection, however, is invalid when practising science as an art.

The only really deterring objection was the prospect of having to cross the Atlantic time and again for half a decade: inconvenient, expensive and inefficient. Nothing would ever have come out of it had it not been for ESO staff—astronomers and administrators—and some visiting astronomers, who put invaluable effort into the project.

Observations

The observations started in April 1976 at the coudé spectrograph of the ESO 1.5 m telescope and were in the beginning carried out mostly by visiting astronomers. Later the need for a coordinator at La Silla was felt, and first Jean Surdej and later Patrice Bouchet made much of the spectroscopic observations. Plates were obtained at 20 Å/mm both in the blue and the red spectral regions.

A first eclipse could be expected in the beginning of October 1977. At this time of the year HD 161387 is difficult to observe since it is close to the horizon and setting early in the evening. We felt, however, that it would be nice to be sure that the star was still on the Swope schedule and we were glad to get a rough confirmation of this by occasional photometry carried out mainly on the ESO 50 cm telescope during August–November 1977.

In the beginning of the spectroscopic part of the programme we applied for a number of fractions (2/3) of nights spaced all through the season of possible observation (March–October). Then nights were shared with other observers. Later, on the initiative of the programmes committee, whole nights were assigned to the project, the reason probably being a need for unambiguity of responsibility. This was an advantage of course—however coupled to an increased vulnerability to bad weather. It opened the possibility of observing other objects similar to HD 161387 at times when our main programme star was below the horizon, mainly at the beginning and end of our observing season.

As the years went by, more plates were accumulated and the next eclipse of HD 161387 in May and June 1980 was in part covered spectroscopically and photometrically though observations were hampered by the weather conditions of the season. The observational part of the programme ended in March 1981, 5 years after the first plates were obtained.

During these years of observations, we made only provisional evaluation of the incoming material, enough for a correct direction of the project. There were many reasons for this. The material needed homogeneity of reductions. We had other obligations of official and private nature. But the main reason was our lack of financial support. Not until July 1981 came the opportunity to put a major effort in the reduction work which is now well under way. Then we found that one of the spin-off stars of the project was very interesting:

The BM Eridani Saga

BM Eridani is one of 2,017 variable stars brighter than the 10th magnitude which were studied from 1938 onwards by the Gaposchkins. Sergei Gaposchkin reports in *Astron. J.* **52,** 43 (1946–47) about a drop in brightness of a star "in the field of YY Eridani" during 1944. It got the variable name BM Eridani. The change in photographic magnitude is approximately 0.8 magnitude: from 8.5 to 9.3. In December 1944 Gaposchkin got a spectrum of the star and found it to be an M6 giant. There was no trace of a secondary spectrum.

Fig. 2: *Astronomer in Library – a most powerful instrument for past observations.*

In 1953 Gaposchkin published in the *Harvard Annals* the results for the eclipsing binaries. There are 281 stars with an average of 1,000 observations for each binary. Here we find BM Eri which had been followed on Harvard patrol plates from March 1888 to December 1945. Altogether 1835 measurements were then available and Gaposchkin concludes that the star had one single minimum in 1944 lasting for less than 321 days. Only the first part of the eclipse could be followed and when the star was observed again the eclipse was over. He gives the period "over 53 and possibly over 57 years".

If there really is a period! If this in fact is an eclipsing binary! But Gaposchkin had some good reason for believing so. The shape of the light-curve looks typical. There is a flat minimum indicating that the secondary component is totally eclipsed. There is an ingress phase lasting for about 25 days which is consistent with a model of an extended atmosphere of the M giant gradually dimming the light of a much smaller star. Gaposchkin had an outstandig experience in handling the plate material of the Havard variable programme, so there is good reason to be confident in his judgement that the drop in brightness is real and not a construction from poor data. It is true that intrinsic variations of M stars are frequent and later BM Eri was found to vary with an amplitude of 0.2 in the V-magnitude. But 0.8 in the blue, that is too much. Still there is no trace of any other star in the spectrum. From the light-curve one would expect a hot star of approximately the same absolute magnitude as the primary. Then why is it not seen?

We went searching the literature for more photometric work on this star. There were not many, but the ones we found turned out to be very interesting. They can be summarized in the following table together with a recent observation made on our request.

Year of observation	Magnitude			Reference
	V	I	K	
1966		4.48	1.28	Neugebauer, Leighton, Two micron survey, NASA 1969
1970	8.06	4.46		Stokes, *Mon. Not. R. Astr. Soc.* (1971) **152,** 165
1972	7.29			Hilditch, Hill, *Mem. R. Astr. Soc.* (1975) **79,** 101
1981			1.27	Fridlund, private communication

Strangely enough we find that the V-magnitude differs by about 0.8 magnitudes between the 1970 and the 1972 measurements. Was BM Eri in eclipse during the observations of 1970? Without the I-magnitude being affected at all, and with a drop in the V-magnitude equal to the photographic magnitude change during the 1944 eclipse? The 1972 observers make no reference to the 1970 one, so the discrepancy has probably not been noticed before. Somewhat astonished, we concluded that we had found an eclipse in the library (Fig. 2). However, the conclusions should not be drawn too hastily since the number of observations is low. Luckily we had an almost immediate opportunity to get some more: In December 1981 Malcolm Fridlund from the Stockholm Observatory obtained photometric measurements in the infrared. While still awaiting the final reductions, we find that the K-magnitude is very close to the 1966 value and from the other colours we make the preliminary conclusion that our invisible secondary star is exactly that: not

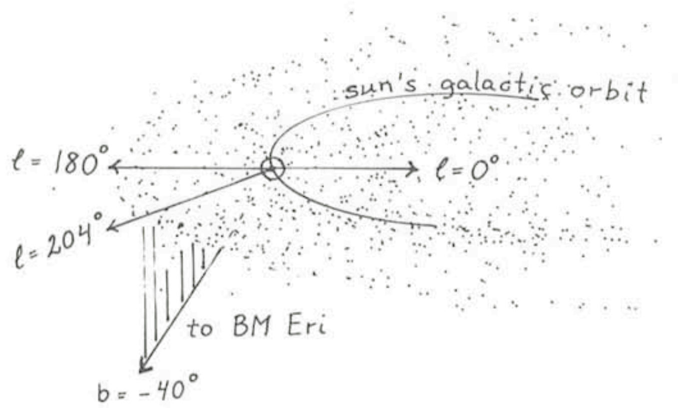


Fig. 3: *BM Eridani is at least 400–800 pc off the galactic plane, a population II giant of high luminosity.*

in the visible but showing up as embedded in dust, radiating in the infrared.

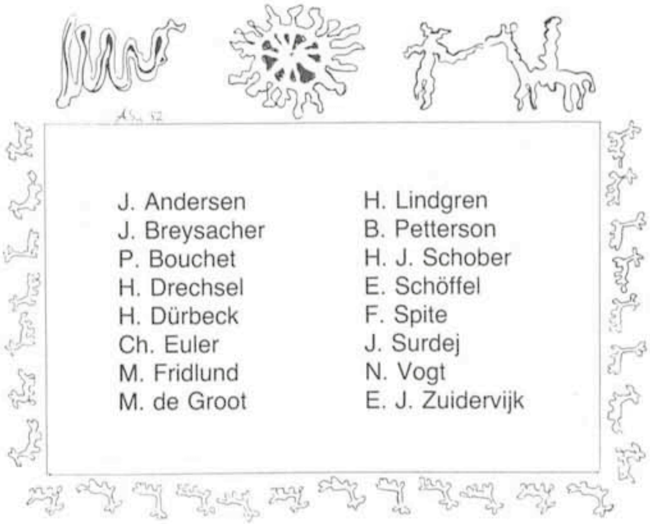
Then what kind of star could that be? BM Eridani is situated at least 400 pc below the galactic plane (Fig. 3). It is probably an "old disk" star and the companion to the M giant could not be too young. That is what can be said for the moment; we will be able to present an estimate of the absolute magnitude from the width of the emission in the K-line—the Wilson-Bappu effect—and also the radial velocity of the system. Most probably the long period and the slow internal motions of the components in this phase will not allow radial velocity changes with time to show up in our present data.

The reason for including BM Eridani in the observing programme was its status as a long-period eclipsing binary, but that is not the whole truth: Another good reason was its situation in the sky, nicely observable when HD 161387 was not up. It just happened like that.

"Tracking something," said Winnie-the-Pooh very mysteriously.
"Tracking what?" said Piglet, coming closer.
"That's just what I ask myself. I ask myself, What?"
"What do you think you'll answer?"
"I shall have to wait until I catch up with it," said Winnie-the-Pooh.
(A. A. Milne, Winnie-the-Pooh, 1926)

Acknowledgement

It is a pleasure to thank the visiting astronomers and ESO staff who made the HD 161387 observation project possible:



Frame inspired by the stone paintings in the surroundings of La Silla.

The Photometric Reduction Service on La Silla

R. Barbier, ESO-La Silla

Observing with a photometric telescope needs interaction from the astronomer: he is the one who can exercise the soundest judgement on how to proceed with his programme. He will for instance decide to change instrumental parameters such as integration time, sequence of filters, diaphragm . . ., or to reobserve a given object which was not measured accurately enough or which shows interesting variations.

Those decisions are reached after a careful examination of the results. Raw numbers, such as counts, do not lend themselves easily to the operation but have to undergo a prior transformation which, in its simplest form, will yield on-line magnitudes that may include or not corrections for zero-point and average extinction. That kind of facility is included, for ESO telescopes, in the data-acquisition programme. An off-line service is also offered to the visiting astronomers to La Silla, the "quick-look reductions". Its main goal is to provide the observer with data where systematic trends coming from non-standard extinction and colour transformation have been removed, thus giving a much clearer idea of what the results are and making the previously mentioned decision-taking procedure easier.

During daytime, an operator saves the raw data from the previous night onto magtape and disk and reduces them, abiding by any special wills expressed by the astronomer. This is by no means an easy task, above all when some data come to him without any indication about source, telescope, photometric system used, names and magnitudes of standard stars . . . For best efficiency, the astronomer should either contact the operator and explain his needs to him, previous to the observations, or go to the computer centre and reduce the data himself, alone or with the help of the operator. Anyhow, if the astronomer is not present during the reductions, they should normally not be thought of as being final. Definitive ones are to be made by the user either in his home institute or at the end of his run on La Silla, using there the available programmes.

The procedure thus briefly outlined has now been in use for several years, since 1974 when Frank Middelburg wrote "REDUC". Many thanks are certainly due from the users' community to the past and present operators, Francisco Browne, Saul Vidal, and Raimundo Arancibia, for the numberless hours they spent since then, giving the visiting astronomers that service.

REDUC can handle the main photometric systems that are used on La Silla, i.e. UBV, uvby, H-Beta, VRI. However, some observers are coming with their own filters for special applications, and new photometric systems are being installed with non-ESO telescopes on La Silla, all cases where no reduction can be done with REDUC. The need for more flexibility in the programme was also expressed by several users.

The basic approach of REDUC, a set of subprogrammes dedicated each to one particular photometric system, makes it rather cumbersome to modify it to accept new standard systems, and impossible for user-defined ones. It was therefore decided to try and write a new programme wherein the system structure, i.e. the way magnitudes or measurements in a filter are transformed to the colour indices system, would be defined in a matrix representation. Also needed in that scheme are symbolic arrays that are used to store the shape of the colour transformation equations, the expression of the extinction coefficients (their possible dependence on one of the colours). Usual systems such as UBV, VRI, UBVRI, uvby, VBLUW, H-Beta are then particular cases and standard values for the previously mentioned matrices and arrays can be simply loaded by specifying the name of the photometric system and telling the programme that the standard procedures for colour transformation and extinction computation will be followed. This means for instance that the colour equations have the form most often found in the literature, that colour-dependent extinction coefficients, if any, are not computed but are given standard values . . . Different weights can be given to the measurements used for the least-squares fitting of the coefficients. When the system is a non-standard one or when the default procedures for a standard system are felt not to be adequate, the user has to fill in part or all of the matrices and arrays. Graphic displays help the user to search for systematic effects like drift, non-linear colour transformation equations, errors correlated with the position of the telescope, wrong dead-time correction, etc.

More information on the possibilities of the programme can be found in a first version of the User's Manual, available on La Silla.

The new programme has already been in use for several months and is being improved thanks to constructive remarks coming from the users, helping to enlarge the original definition of main goals and features outlined with the cooperation of Patrice Bouchet and Christian Perrier, from the ESO staff. It is to be hoped that through that feedback from the visiting astronomers, the photometric reduction service on La Silla will further increase in quality, for the benefit of the whole users' community.

Fire Brigade and Rescue Squad

by J. Peñafiel, ESO

An emergency is defined as an unforeseen combination of circumstances which can lead to danger of human life and to damage of property, requiring immediate action.

In order to be prepared for this "immediate action", two groups were formed by the safety engineer at La Silla: a fire brigade and a rescue squad. Whilst the tasks of the former group may be clear to everybody, the latter one's aim is to intervene in the case of technical accidents, e.g. a car accident.

Both groups consist of volunteers of the local personnel coming from various departments. The members are trained for the multiple difficult situations, which might occur during an emergency operation at our observatory. They acquired general knowledge about the development of fire and the strategies of its combat in the first group and about situations in which confined persons are to be released during accidents of traffic, snow or earthquakes in the second group. They all know how to handle a case of first aid and how to transport unconscious, injured or panic-stricken persons.

All training is done in simulated cases, mock fires of combustible material and inflammable liquids existing at the observatory were attacked and extinguished with the adequate means: water, foam, powder. The operation of the fire-fighting truck and the handling of its various equipment is frequently rehearsed. Practical exercises and theoretical lessons are organized once per month. The rescue squad is trained continuously in first aid and the use of their tools as saws, tongs, rigging and jacks. You certainly saw their brown vehicle at the Pelícano air strip.

Up till now there were fortunately only very few real and serious cases of emergencies, but during these the groups have proved their efficiency in "immediate actions".

Here are two examples of activities of the rescue squad:

August 25, 1980: 15 hours snowfall. The rescue squad cleaned roads, saved vehicles caught by snow or mud, towed the bus with personnel through a miry part of the road, searched the buildings for isolated persons and brought them to the hotel.

January 4, 1982: 14.40 h: a car Renault R4 leapt off the road 300 m before the gate at Pelícano. The rescue squad led the two injured passengers to the porter-house and administered first aid until the arrival of the ambulance.

An early photograph of Santiago. *This picture was taken around 1905 from the Manuel Foster Observatory of the Catholic University (Cerro San Cristobal) by Dr. William H. Wright, director of the Observatory.*

It shows the eastern part of Santiago and, more precisely, the site of the suburb of Las Condes. On the right is the Cerro San Luis (3) with, on its left, the Vitacura crossroad from which starts the President Kennedy avenue (5) and the Vitaçura avenue (4). The small mountain on the left (1) is the Cerro Albarado (1,026 m). The line of poplars (2) along the rio Mapocho shows the present-day tracing of the Avenida Andres Bello (ex Costanera).

The location of the ESO offices is shown by the arrow. (Photograph communicated by M. Gaston Le Cerf from the "Pontificia Universidad Católica de Chile – Observatorio Astrofísico Manuel Foster and M. Patrice Bouchet, ESO-La Silla.)

Una temprana fotografía de Santiago. Esta fotografía fue tomada alrededor del ãno 1905 desde el Observatorio Manuel Foster de la Universidad Católica (Cerro San Cristóbal) por el Dr. William H. Wright, director del Observatorio.

Muestra la parte oriente de Santiago y particularmente la zona de la comuna de Las Condes. A la derecha se encuentra el Cerro San Luis (3) a cuya izquierda aparece el cruce de Vitacura donde nacen las avenidas Presidente Kennedy (5) y Vitacura (4). El pequeño monte a la izquierda (1) es el Cerro Albarado (1026 m). La avenida de álamos a lo largo del río Mapocho muestra el trayecto de la actual avenida Andrés Bello (ex Costanera). La ubicación de las oficinas de ESO está indicada por la flecha.

(Fotografía por gentileza del Sr. Gastón Le Cerf de la "Pontificia Universidad Católica de Chile – Observatorio Astrofísico Manuel Foster y Sr. Patrice Bouchet, ESO La Silla.)

Italia, país miembro de la ESO

Con fecha 24 de Mayo de 1982 el embajador de Italia en Paris hizo entrega del documento de afiliación en el Ministerio de Relaciones Exteriores Francés, acto requerido según el art. 13 de la Convención de ESO, que atestigua la afiliación de Italia como país miembro.

Es el deseo que esta nueva afiliación de Italia no sólo satisfaga los anhelos de astrónomos y astrofísicos italianos quienes desde ahora tendrán acceso a observaciones ópticas en el hemisferio austral, sino que también contribuya al refuerzo de la Organización y al aumento de su rol básico del desarrollo de la astronomía europea.

Cuerpo de Bomberos y Grupo de Rescate

por J. Peñafiel

Una emergencia es una combinación imprevista de circunstancias que podrían dar por resultado peligro para la vida humana o daño a la propiedad, que requiere una acción inmediata.

Con el propósito de estar preparado para esta "acción inmediata", el Ingeniero de Seguridad en La Silla formó dos grupos de voluntarios: Cuerpo de Bomberos y Grupo de Rescate. Mientras las funciones del Cuerpo de Bomberos parecieran conocidas de todos, las del Grupo de Rescate son intervenir en caso de accidentes propios del trabajo, e.g. accidente de vehículo.

Ambos grupos están formados por voluntarios del personal local provenientes de diferentes departamentos. Los integrantes son entrenados para diferentes situaciones de riesgo, que pueden ocurrir durante una operación de emergencia en nuestro observatorio. Ellos han adquirido conocimientos generales sobre el comportamiento del fuego y estrategias de combate en el primer grupo; y situaciones en las cuales deben liberar a una persona atrapada en un accidente de vehículo, nevazón o terremotos, en el segundo grupo. Todos ellos tienen instrucción básica sobre la administración de primeros auxilios, traslado de personas inconscientes, heridas o presas de pánico, hacia lugares de menor riesgo.

Todo el entrenamiento es realizado a través de simulacros de incendios de materiales combustibles y líquidos inflamables, existentes en el observatorio, los cuales son atacados y extinguidos con los medios adecuados: agua, espuma y polvo. La operación del carro bomba y el manejo de los diversos equipos es conocida por cada voluntario en las charlas y prácticas que se realizan mensualmente. El Grupo de Rescate está preparado especialmente en primeros auxilios y uso de equipos/herramientas, tales como sierras, tenazas, amarras y gatas hidráulicas. Ustedes seguramente han visto su camioneta café debidamente equipada en el aeródromo El Pelícano.

Hasta ahora afortunadamente han habido pocos casos serios de emergencia, pero durante éstos los grupos han demostrado su eficiencia en "acciones inmediatas".

A continuación exponemos solamente dos ejemplos de intervención del Grupo de Rescate:

Agosto 25, 1980: 15 horas de nevazón. Rescate despeja los caminos, retira vehículos atrapados en la nieve o barro, guía a bus con el personal por vía obstaculizada, y revisa edificios para localizar personas aisladas y trasladarlas al Hotel.

Enero 4, 1982: 14.40 horas: un vehículo Renault R4 se salió del camino 300 metros antes de llegar a Portería Pelícano. El Grupo de Rescate trasladó a los ocupantes heridos hacia portería y administró los primeros auxilios, mientras llegaba la ambulancia.

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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