THE MESSENGER

EL MENSAJERO

No. 15—December 1978

Ten Nights at the "Very Large Telescope" (VLT)!

Ever since the ESO Conference on Future Telescopes in December 1977, astronomers have been talking about future *Very Large Telescopes*. But what would they actually do with them? We therefore asked some of the astronomers in the ESO countries to answer the simple (?) question: *What would you observe if you had ten nights on a 25 metre VLT?* We bring their replies in this and the following issue of the *Messenger*.

Uncovering the secrets of the Universe with a 25 m VLT. Drawn by Jean-Claude Pecker who tells about his preferred observing programme with a future giant telescope. Other contributors in this Messenger *issue are Immo Appenzeller, Poul-Erik Nissen, Antoine Labeyrie, Luboš Kohoutek and Jean-Pierre Swings. More will follow in the next issue.*

Clouds in the Halo

J.-C. Pecker

> *Well, what can be done with ten nights on a future 25 metre telescope (the VLT)? The first to send in his article was Professor Jean-Claude Pecker from Collège de France and Institut d'Astrophysique in Paris. He feels that most of the time should be used to study the stars and the gas in the halo of the Milky Way. Join him on the magic carpet . . . but remember to fasten the seatbelts!*

"Experience, till now, gives us hope that human resourcefulness and imagination, combined with enough photons, will find solutions . . ." J.-L. Greenstein.
. . . Yes! . . . But what is more difficult is to find problems!

Evoking the fairy-tales of the Orient, as did Jesse Greenstein (ESO Conference on Optical Telescopes of the Future, December 1977), I feel that my Ten Nights at the VLT have, like the Thousand and One Nights of Scheherazade, a completely imaginary character! When the VLT goes into operation, I am sure that my doctor will not allow me to walk without crutches . . . The magic carpet that brings me there travels more in time than across the oceans, which is not bad at all because the adaptation will be rather difficult.

I have therefore been forced to think a lot before establishing my "dream" programme. A telescope with a diameter of 25 m implies a greatly improved light-gathering capacity and a much better resolution. I admit that the temptation to try to observe "the limits of the Universe" is very large, and also to count the faintest objects somewhere in the sky: but the atmosphere is still there; and I prefer to await a satellite "out of the ecliptic", which is equipped with a telescope of reasonable size, in order to really get rid of the background light from the dust and the interplanetary gas (zodiacal light), or at least most of it.

I think it would be interesting to use the VLT to improve the knowledge of the energy distribution on stellar surfaces. But I am afraid that the VLT in the end will not be better than an array of cleverly arranged smaller telescopes.

On the contrary, the following argument appears reasonable: *at the same spectral resolution, the space volume which can be explored by the VLT is eleven times larger than what can be studied with the Palomar 200" telescope* (remember that the relation between *limiting* magnitude and instrument diameter is given by $m_0 = -2.5 \log D +$ constant because the limit is given by the signal-to-noise ratio, cf. the article by W. A. Baum in *Astronomical Techniques, Stars and Stellar Systems,* II, 1962, p. 5, ff.). It is the study of the spectra of stars and galaxies which has, in general, left me hungry. Some major problems in present-day astronomy are still unsolved because of the lack of statistical significance. The examples are obvious: one can count on one hand (or at least on a few hands) the stars for which the chemical composition has been determined from spectral line measurements; even more rare are the normal stars for which the line profiles have been well measured; and I know only of one star, the Sun, for which the line profiles have well-determined asymmetries (with the exception of some monstrosities, however interesting they may be, like for instance P Cygni). For how many galaxies do we really know the chemical composition in 1978? At the most a dozen. We shall get at least a hundred with the VLT. For how many quasars do we know the spectrum in great detail? Improving the number by a factor of 10 will allow us to avoid risky speculations.

This factor of 10 can, at the same dispersion, be a gain in the *time*-resolving power. The variable stars of type δ Scu or β CMa; the eruptive stars of type T Tau or UV Cet are really not very well known . . . What a harvest we would get from a time resolution of the order of one second in the study of, for instance, the changes of the Ca II (K) or the Hα line profile! Stationary or progressive waves, various oscillations, mass outflow . . . these important evolutionary processes will undoubtedly come within reach.

However, at this point in my thought chain the choice becomes painful! Surely the VLT is situated at a perfect site . . . I therefore really have ten full nights at my disposal—and I have of course chosen the dark, new-moon period! Moreover, from the VLT mountain I can easily observe the galactic centre during my nights.

It is consequently our Galaxy, the Milky Way, that is the subject of my programme. "Our" Earth: the first celestial body to study—the geophysicists have taken care of that. "Our" Sun (or rather "our" solar system): Long live the space probes! (But there is also a lesson to which I return after my tenth night). So now, *"Our Galaxy"*—and we reserve, for the future, "our" local group, "our" super-galaxy, "our" . . . I stop here without prejudice to the extrapolation of this hierarchical playing with Russian dolls! (Cf. the front-page figure, freely after G. de Vaucouleurs, 1970).

The Centre of the Galaxy

The Galaxy, like the Sun and like a cluster of galaxies, is a *condensation of matter immersed in a dilute medium.* As for the Sun, it is the transitional region between condensation and dilution (the atmosphere—in a very general sense) which to a large extent determines the physics. And it is the *physics* of the Galaxy to which I have decided to devote my nights—to its physics and its evolution.

Objective-prism spectra of stars in a fairly large field towards the centre of the Galaxy could be obtained in order to determine the radial velocities of stars very close to the nucleus (a difficult operation in 1978?). The magnitude which is presently reached with the Fehrenbach objective-prism method is about 13^m–14^m with a 60 cm objective: a gain of 6^m may therefore be possible; but the overlapping of the spectra will be a problem. Is it possible to compensate the necessary increase in the plate scale in the focal plane by a sufficient exposure time to reach a reasonable number of stars close to the galactic centre? Will it not be necessary to restrict the study to the near infrared region (1 μm)? And will the techniques for measuring radial velocities be sufficiently accurate? Maybe . . . Too many uncertainties about the possibilities of electronic photon counting in this region of the spectrum do not allow me, now in 1978, to know if I shall be able to use the VLT in such a mode in the year 2000.

The Galactic Halo

But if I cannot be sure to determine accurately the kinematics at the centre of the Galaxy I can at least study that of the halo.

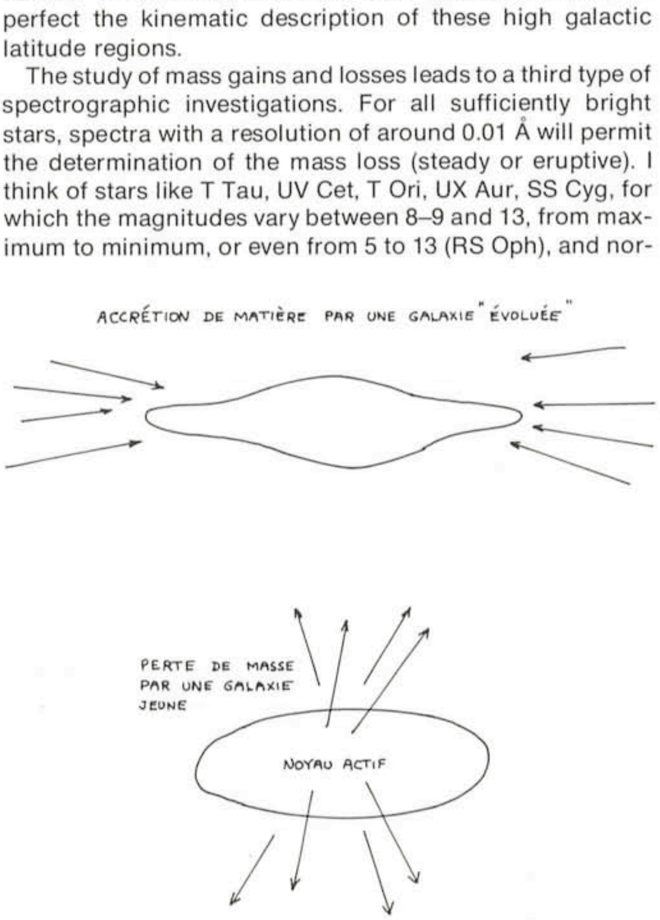
I therefore devote my programme to the very fundamental study of the *mass gains and losses of the Galaxy* (see the figure on this page) after ideas by Pecker (1972, 1974, 1978) and Pecker and Vigier (1976)).

The first, obvious question: to study the Oort clouds and the Dieter ring—neutral hydrogen which has apparently been collected by the *galactic equator*. This neutral hydrogen (which has been observed in the 21 cm line) ought to be connected with other, visible components (dust emitting in the infrared, calcium absorbing in the K-line, H II regions and emission in Hα). These regions must be investigated with great care; in particular the galaxies which are seen behind the clouds should be observed spectroscopically in order to detect absorption structures.

The same programme should also be carried out towards the *galactic poles* . . . One of these will be observable from the VLT mountain. Spectra should be obtained of galaxies near galactic longitudes 0° and at latitudes ranging from 0° to 90° with the aim of observing the fine structure of the interstellar absorption (certainly H und K, maybe 4430, obviously the CN-bands, and if possible (!) Hα, which must be shifted sufficiently in wavelength from the Hα of the studied galaxies to become observable).

If all goes well, these spectra could also give the variation in chemical composition H : N : C : Ca in the halo of the Galaxy. To this must be added the spectra of supergiants and halo stars, including spectra of cluster stars at the highest possible resolution. It is also necessary to increase the number of known radial velocities for halo stars in order to perfect the kinematic description of these high galactic latitude regions.

The study of mass gains and losses leads to a third type of spectrographic investigations. For all sufficiently bright stars, spectra with a resolution of around 0.01 Å will permit the determination of the mass loss (steady or eruptive). I think of stars like T Tau, UV Cet, T Ori, UX Aur, SS Cyg, for which the magnitudes vary between 8–9 and 13, from maximum to minimum, or even from 5 to 13 (RS Oph), and normal stars—those which serve to calibrate stellar classification schemes. The best possible time resolution should obviously be obtained at the given spectral resolution and some long time-sequences will be observed.



Accretion of mass by an evolved galaxy and mass loss by a young galaxy with an active nucleus.

The VLT Programme

Did I use my ten nights? A thousand and one more likely!

So therefore a limited programme: one night with very highly resolved Hα profiles of the brightest stars in the sky; one night on T Tauri (which has many sisters); three nights to explore, as a function of galactic latitude, bright galaxies in order to detect interstellar lines from the gas in the halo of our Galaxy; three nights on similar research in the direction of the Oort clouds, the positions of which are well known from 21 cm observations; and finally two nights with spectra of various stars at high galactic latitudes at distances of 20 to 60,000 pc from the Sun.

And that is the end of the observing run . . . But will we have the necessary computers to support this exploration? And shall we have—with the present situation in European astronomy—a sufficient force of young astronomers for the reductions? It is not enough to get the spectra and to ask the questions: time and equipment are necessary to get through. The case of the Sun is, unfortunately, typical in this and many other respects: there are ancient observations, even very ancient ones, which have never received a satisfactory interpretation! The eleven-year cycle, for instance . . . And, besides, what a flood of high-precision, modern observations which could undoubtedly result in an improved knowledge of the physics of the Sun, but which overwhelms the computers and even the physicists (magnetic structures in solar eruptions, oscillations in the supergranularity).

In other words, I am afraid that it will sometimes be necessary to postpone the interpretation of certain new data from the VLT and to limit the immediate effort to the explanation of outstanding discoveries.

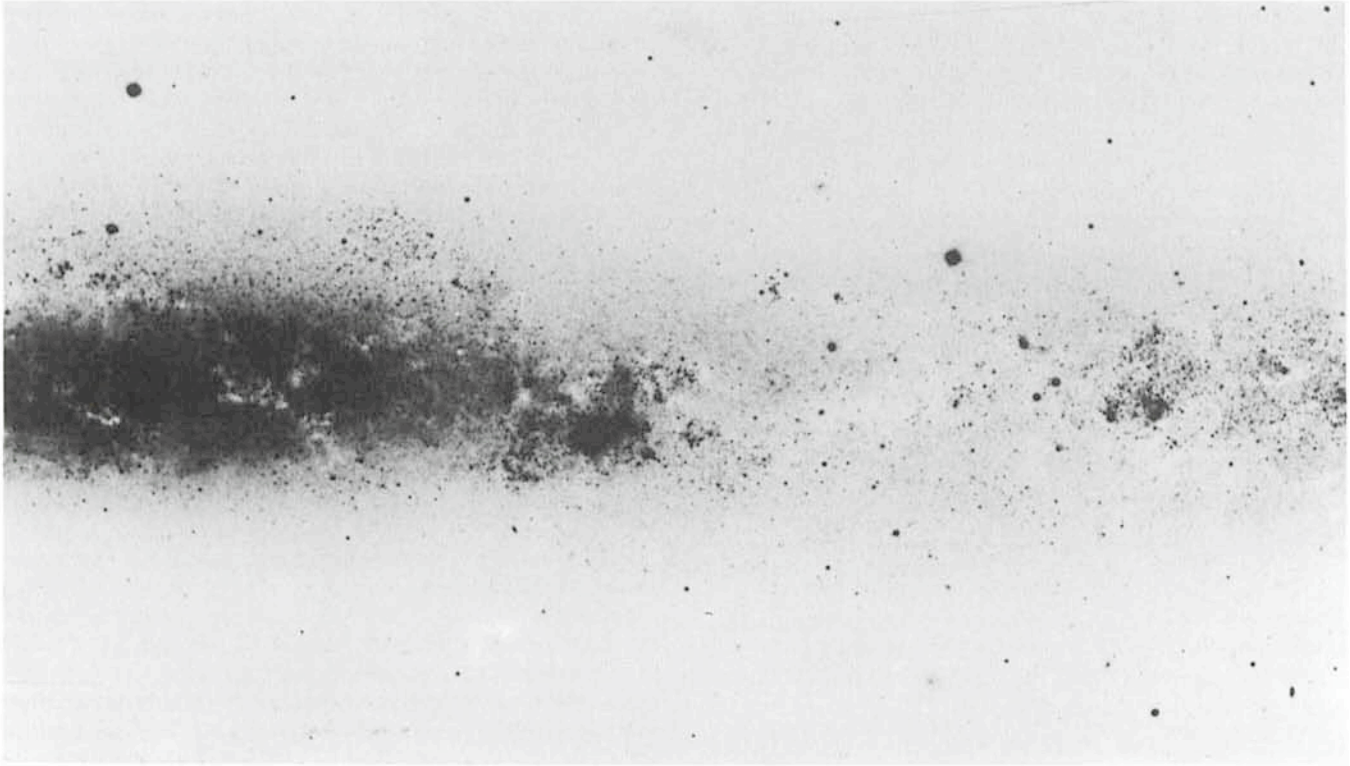
As in numerous other chapters in astronomy, the use of the VLT will therefore give rise to much bitterness! That of the observer, who after having made a step forward, soon encounters new borders. That of the theoretician (but has the distinction really a meaning? We are all more or less both) who will find himself unable to carry through unambiguously the analysis of a very high dispersion spectrum or who, in order to study what he believes is the most important, has to postpone something else, which a more detailed study subsequently reveals as being even more important.

Likewise, the use of the VLT will also give rise to many interesting surprises. A spectrum of a galaxy obtained for the study of galactic interstellar lines may reveal new properties of this galaxy . . . Looking for mushrooms in the forest, one discovers a treasure!

If the magic carpet of my astronomer's dream has carried me to such a distant extrapolation, the time has now come to ask for absolution! It is the rule of the game. But the study of the evolution of our Galaxy is certainly worth a moment of joyous distraction . . .

References

J.-C. Pecker, 1972, *Astron. and Astroph.,* **18,** 253.
J.-C. Pecker, 1974, *Astron. and Astroph.,* **35,** 7.
J.-C. Pecker, 1978, Astronomical Papers dedicated to Bengt Strömgren, Eds, A. Reiz and T. Andersen, *Copenhagen Univ. Obs. Publ.,* p. 285.
J.-C. Pecker, J.-P. Vigier, 1976, *Astrofizika,* **12,** 315.
G. de Vaucouleurs, 1970, *Science,* **167,** 1203.



Individual stars in NGC 55, a large galaxy in the nearby Sculptor group of galaxies. The plate was obtained in the prime focus of the 3.6 m telescope in December 1976, by Dr. S. Laustsen. IIIa-J + GG 385, 60 min.

Stars in Other Galaxies and Protoplanets

I. Appenzeller

> *Will the VLT find planets around other stars where there could be life? Dr. Immo Appenzeller from Landessternwarte Heidelberg-Königstuhl would like to try. He would also like to observe individual stars in other galaxies and to determine element abundances outside the Milky Way. Is the chemical composition the same everywhere in the Universe?*

Having been informed that 10 nights on the just completed VLT have been allotted to my observing programme, my first reaction would probably be to call VLT headquarters to ask whether perhaps a decimal point was omitted between the one and the zero in the number of nights. After all, past experience allows to derive a rather well-defined relation between the number of nights allotted to a given observing programme and the cost of the instrument used. If we extrapolate this relation (based on the allocation schedules of the major ground-based or satellite-based optical telescopes presently available to European astronomers) to 2×10^8 SF (the conventional estimate of the cost of a VLT) we obtain with good approximation 1.0 night per application. Of course, extrapolations can be wrong. Nevertheless, while I regard it as fairly realistic to assume that a VLT will be brought into operation sometime before the end of this century, it appears considerably less realistic to expect that any European astronomer will ever get a block of ten nights at this valuable instrument.

Assuming now that a sizable amount of observing time on the VLT has indeed been put to my disposal and assuming furthermore that at the time when the VLT has become operational I am still interested in the same topics which I am working on right now (which, considering the time scale on which I changed my main fields of interest in the past, will almost certainly *not* be the case) I would use the observing time in the following way:

Protoplanets

About 30 per cent of the available time would be used to obtain high angular resolution images either by speckle interferometry and image reconstruction or perhaps by some other advanced method (e.g. "active optics") which is able to eliminate the distorting effects of the earth's atmosphere. The objects to be observed would be low-mass protostars or very young solar-type stars. The motivation for these observations follows from the following considerations: In my opinion, one of the most important astronomical problems to be solved in the near future is the question if, where, and what kind of life exists (or may exist) outside our own tiny planet Earth and outside our solar system. As noted by many authors, an obvious first step in this direction would be to look for other planetary systems and to study their physical parameters and conditions. Since such life-supporting planets of distant stars are expected to be relatively faint objects seen very close to much brighter stars, their direct investigation will be very difficult even with the VLT. On the other hand, according to present theories, planetary systems may be much more conspicuous objects ("protoplanetary discs") during their formation. The closest region in our Galaxy where ongoing star formation has been observed is about 100 pc away. Thus, in order to observe features of the size of the earth's orbit, an angular resolution of about 0".01 is needed. A VLT could not only provide (in principle at least) the required angular resolution but also (and this is even more important) a sufficient amount of photons to allow the use of methods like speckle interferometry on such relatively faint objects.

Stars in Other Galaxies

Having finished the part of my observing programme described above, I would still have 70 per cent of the allotted time left. I would use this larger part of my observing run entirely for medium or high dispersion spectroscopy of stars in nearby extragalactic systems. (Of course, I am also very much interested in spectroscopy of various types of galactic objects. However, for all my pet galactic objects there exists a sufficiently bright specimen which can be observed at any required spectral resolution with existing telescopes if up-to-date detectors and effective spectrographs are used.) The extragalactic part of my VLT observing programme would have the objective to determine the physical parameters (i.e. effective temperature, radius, mass, chemical composition, etc.) of some of the stars which make up these nearby galaxies. Thanks to high dispersion spectroscopic work on galactic stars and thanks to the refinement of our methods to analyse stellar spectra, the physical properties of the normal galactic stars are by now relatively well known. In extragalactic systems only a few bright stars in the Magellanic Clouds have ever been observed spectroscopically in some detail. For all other galaxies we simply *assume* that their stars basically have the same properties as those in our own Galaxy. On the other hand, nonstellar objects (like H II regions and globular clusters) that are bright enough to have been studied in extragalactic systems in many cases show significant differences when compared to their galactic counterparts. Therefore, I would not at all be surprised to find in extragalactic systems stars with (e.g.) higher mass or higher metal content than observed anywhere in the Galaxy. Since the nearby galaxies play an important role in establishing our extragalactic distance scale, such results may have profound effects on our knowledge of the large-scale structure of the Universe. Some work in this direction (e.g. in the local group of galaxies) can probably be done with our existing optical telescopes if modern detectors are used. However, in order to do even medium resolution spectroscopy of single stars in such important nearby galaxies as M 101 nothing less than a ground-based VLT will suffice.

Of course, there are many other interesting but at present "impossible" astronomical problems that could be tackled with a VLT. The questions described above are only those which I would attack first with this instrument. Having written these lines, my biggest question now is whether the observing programme outlined above will remain (science-) fiction or whether I shall indeed sometime have a chance to push the buttons and bang my head in the dark at the VLT!

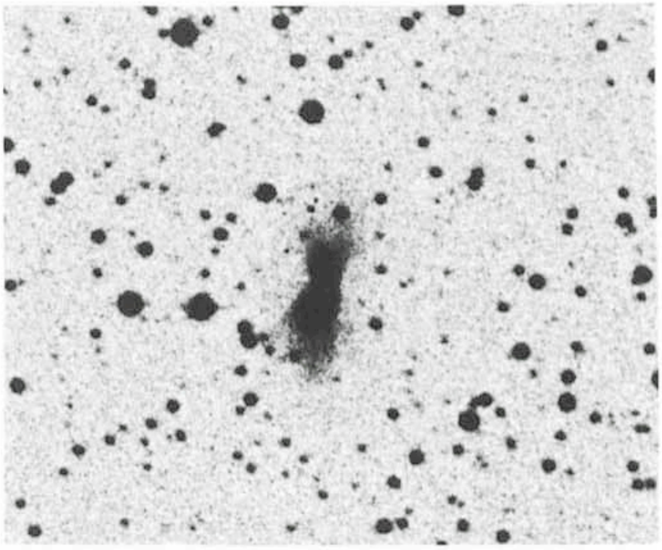
A New Bipolar Nebula in Centaurus

Looking through large Schmidt plates can be a rewarding, but sometimes also a somewhat frustrating business. Depending on the colour of the plate and on the exposure time, otherwise normal objects (galaxies, nebulae) may reveal features that make their classification difficult. A direct Schmidt plate says nothing about the spectrum of the objects, except when it is compared with other plates in other colours.

Thus, there are many objects on the one-colour ESO (B) Atlas which have to be described as just "peculiar", until their spectrum has been observed. One of these was found during the ESO/Uppsala survey of this atlas and also independently by two astronomers at the South African Astronomical Observatory, Drs. G. Wegner and I.S. Glass. It was designated as 172-?07 by the ESO and Uppsala astronomers who frankly did not know whether it was a galaxy or a nebula in the Milky Way.

Some light has been thrown on the nature of 172-?07 by the South African astronomers who recently obtained spectra of the object with the 1.88 m reflector at Sutherland. They find that only absorption lines are visible and that the spectral energy distribution corresponds to about spectral type F0. However, infrared observations with the same telescope reveal a clear IR excess, i.e. the object is brighter in the infrared than one would expect from the visual magnitude.

Wegner and Glass speculate whether 172-?07 is a pre-main sequence object, in which an envelope of dust shrouds a star that is contracting out of this dust. But most objects of this class show emission lines and it is therefore clear that the mystery about 172-?07 has not yet been solved.



ESO 172-?07, a bipolar nebula in Centaurus, photographed with the ESO Schmidt telescope on IIa-O emulsion, through a GG 385 filter. Exposure time 60 min.

The Chemical Composition of Stars in Open Clusters

P. E. Nissen

Until now few high-dispersion spectra have been obtained of stars in galactic star clusters and most of the spectra are of giant and supergiant stars that are very difficult to analyse. To reach fainter clusters and intrinsically fainter (main-sequence) stars in the nearer clusters, more photons are necessary. This is exactly the great advantage of the VLT, and Dr. Poul Erik Nissen of the Astronomical Institute in Aarhus, Denmark, explains how he would like to carry out such a programme.

It is in principle possible to find the chemical composition of a galaxy as a function of position and time by measuring abundances of stars with different birthplaces and ages, provided that their atmospheres represent the composition of the gas from which they were formed. Such studies may therefore give important information about the chemical evolution of galaxies and even about the composition of the matter in the very early phases of the Universe.

The fact that the relative abundances of the elements in the solar atmosphere agree so well with the relative abundances found in meteorites indicates that solar-type stars, i.e. late F and early G main-sequence stars, have indeed the same atmospheric composition as the material out of which they were formed. Also the composition of most nearby B main-sequence stars agrees well with the composition of interstellar matter as found from observations of H II regions. On the other hand the atmospheres of red giants are at least in some cases contaminated by elements produced in the star itself. The same may be the case for supergiants, and apart from that, it is very difficult to derive reliable abundances for such stars because of their complicated atmospheric structure. Thus giants and supergiants are more questionable as tracers of composition in galaxies, and I shall not consider them in the following.

How Far Will the VLT Reach?

In order to derive detailed abundances of an F or G star we must observe its spectrum with a resolution of about 0.1 Å. With a lower resolution too many lines in the spectrum overlap and the continuum is not well defined, so that the equivalent widths of weak absorption lines—most suitable for abundance work—cannot be measured with sufficient accuracy. Furthermore the noise must be as low as 2 per cent, which means that about 2,500 photons have to be counted per 0.1 Å, assuming that the photon shot noise is the dominant error source.

Bearing in mind that the flux of a star of visual magnitude $V = 0\overset{m}{.}0$ is 10^3 photons $\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{\AA}^{-1}$ and assuming that the telescope, spectrograph and detector have an overall efficiency of 5 per cent, it is easy to calculate that with a 3.6 m telescope it will take about 4 hours to detect 2,500 photons per 0.1 Å for a star of $V = 16^m$. The corresponding magnitude for a 25 m telescope is $V = 20^m$. This may be considered as limiting magnitudes for detailed abundance work on F and G stars, as one hardly wants to spend more than 4 hours on one star. For B-type stars we may be able to go about one magnitude fainter because a resolution of 0.25 Å will be sufficient to resolve their less crowded spectra.

I should remark here that since the efficiency of present-day telescope-spectrograph-detector combinations is not as high as 5 per cent, a limiting magnitude of about $14\overset{m}{.}5$ is probably more realistic, for example with the ESO 3.6 m echelle spectrograph that is now under construction. However, I expect that the detector efficiency will be improved from about 0.20 to 0.60 in the (near?) future so that an overall efficiency of 5 per cent can be achieved.

The limiting distances for abundance work corresponding to the estimated limiting magnitudes are given in Table 1 for an F8 V star and a B0 V star. The case of an interstellar absorption of 2^m is applicable for studies of stars in the outer regions of the galactic plane.

Table 1. Limiting distances for detailed abundance determinations of stars for a 3.6 m and a 25 m telescope.

Spectral type	Interstellar absorption	Absolute magnitude	Limiting distances 3.6 m	25 m
B0 V	0^m	-4^m	160 kpc	1100 kpc
B0 V	2	-4	63	440
F8 V	0	4	2.5	17
F8 V	2	4	1.0	7

It is seen that with existing telescopes it is possible to perform abundance studies of B main-sequence stars in a major part of our galaxy and even in the Magellanic Clouds. However in order to reach B stars in a few nearby spiral galaxies, e.g. M 31, M 33 and IC 1613, a 25 m telescope is essential and I expect this to be an important programme for the VLT.

Evolution in Time and Space

In case of F and G-type stars it is seen from Table 1 that existing telescopes can reach only the solar neighbourhood, whereas the VLT can cover a substantial part of our galaxy. With such a telescope it will be possible to study the unevolved stars in a number of globular clusters and thus to solve one of the presently most interesting astrophysical problems: Are the different abundances found for the giant stars in certain globular clusters, e.g. in ω Cen, of primeval origin or are they a result of stellar evolution? However, I shall leave this interesting investigation to somebody else and concentrate on a study of abundances of stars in open clusters.

As far as we know, all stars in a given cluster are formed at about the same time, with the same chemical composition,

Fig. 1: *NGC 6025, $\alpha_{1950} = 16^h00^m$, $\delta_{1950} = -60°22'$. According to Feinstein (P.A.S.P.* **83,** *800, 1971) this cluster is at a distance of 760 pc and has an age of 10^8 years. The brightest stars are of magnitude 8^m, whereas the late F and early G dwarfs are around 14^m. From the ESO (B) Atlas.*

and are moving with nearly the same space velocity. By averaging observational data for a number of stars in a cluster it is therefore possible to determine its distance, space velocity, composition and age much more accurately than can be done for a single field star. Especially the age of a cluster can be determined fairly accurately by the aid of the turn-up from the main sequence in a colour-magnitude diagram, whereas the ages determined for individual F stars are very uncertain because they evolve so slowly.

This is the main reason why open clusters are such excellent tracers of the chemical evolution of our galaxy. By studying them we will hopefully be able to solve two main problems in modern astronomy, namely, how has the composition of the galactic disk evolved in time and in which way does the composition vary as a function of position in the disk at a given time? If these questions can be answered for a number of the most important elements such as H, He, the CNO group, the α-particle elements, the iron group, and the r and s process elements, then we will have a good possibility to discriminate between different models of evolution of galaxies. Furthermore we will gain new insight into a number of important astrophysical problems: What was the initial composition of our galaxy or in other words, which were the end-products of the big-bang phase of the Universe? In what quantities are the different elements synthesized and ejected from stars of various masses? In which way does the initial mass function for stars vary as a function of time and position in our galaxy?

The Initial Programme

With these general ideas in mind I shall briefly outline how much we already know about the variation of the chemical composition of the galactic disk in space and time, and what we may expect to learn from the observations with the VLT.

Considering first the abundance of the disk as a function of time, we note that earlier findings of a correlation between metal abundances and ages for disk population stars have been questioned as being due to selection effects. However, I think that the statistical analysis by Mayor (*Astron. Astrophys.* **48,** 301, 1976) of nearby F dwarfs, for which the Strömgren m_1 index can be used as a metal abundance indicator, shows that the galactic disk at the solar distance from the centre has been enriched by a factor of 2 in metals during its lifetime. A study of, say, 25 open clusters of different ages with about the same birthplaces would give a much better value of this factor and may reveal if it is different from element to element. As most of these clusters probably can be found within 1 kpc from the sun this part of the programme can be carried out with existing large telescopes.

The VLT Study of Distant Clusters

The second part of the programme, i.e. the determination of possible abundance gradients in the galactic disk, requires however the VLT, because in this case it is important to be able to study clusters at distances of up to 6 kpc or so. Recent work has shown that large-scale abundance gradients are indeed present in the disk. I may refer again to the work of Mayor, who found a decrease of the metal abundance by a factor of 2 over a distance of 3 kpc in the radial direction. Abundance determinations of H II regions (Peimbert, IAU Symp. **84,** 1978) have revealed a similar radial gradient in oxygen abundance and even larger for nitrogen. The latter method is very powerful because the light from H II regions is *emitted* in the spectral lines that are used in the abundance studies. One may therefore ask whether a study of abundance gradients by the aid of *absorption* lines in star clusters is of any interest compared to this method. I think so, first of all because it is very important in science that the same problems are studied with entirely different and independent techniques, secondly because the abundance determinations of stars probably are more accurate than those of H II regions, and thirdly because the stars allow studies of a number of interesting elements that are not represented in the spectra of H II regions.

A certain class of open clusters is of particular interest, when we want to determine abundance gradients, namely those clusters that are young enough to contain B main-sequence stars of spectral types earlier than B7 and old enough to contain F stars that have contracted to the main sequence. These clusters have a turn-up from the main sequence between spectral types B2.5 and B7 and their ages lie between 25 and 100 million years. Well-known examples are the α-Persei cluster and the Pleiades. For such clusters we have the interesting possibility of determining abundances for both the B stars and the F stars. It means that certain elements, that are not seen in the spectra of F stars, e.g. He and Ne, or are poorly represented, e.g. C, N, and O, can be studied for the B stars and vice versa.

After having tried to justify my observing programme, it may now be defined as follows: A number of clusters of the above-mentioned type with distances from the galactic centre between 7 and 16 kpc will be selected, and in each cluster high resolution spectra of 3 F-type stars will be observed. If we estimate the average observing time to be 2 hours per star it means that a total of 16 clusters can be studied during the 10 nights that are available. Figures 1 and 2 show two clusters that probably will be on the programme, namely NGC 6025, a relatively nearby cluster, and Basel 4, one of the most distant known open clusters.

Fig. 2: *An. Basel 4, $\alpha_{1950} = 5^h47^m$, $\delta_{1950} = 30°09'$. According to Svolopoulos (Z. f. Ap.* **61,** *97, 1965) this cluster is at a distance of 5.9 kpc and the age is probably around 25 million years. The brightest B stars are of 13^m, and the late F dwarfs have magnitudes of 19–20^m. From the Palomar Atlas.*

Preparation

It is clear that such a programme at the VLT has to be prepared very well in advance and that many supporting observations should be carried out with smaller telescopes. Most important will be: Photoelectric uvby and Hβ photometry in order to determine distances and ages of the clusters. Radial velocity and proper motion measurements in order to derive space velocities. Medium-dispersion spectroscopy to get spectral types and information on possible peculiarities or duplicity. These different types of observations will also serve to determine membership of the clusters. They can all be carried out with existing telescopes, except the proper motion measurements. For the most distant clusters they should be as accurate as $\pm 0''.0002$ year^{-1}, and that can only be achieved by the Space Telescope with a reasonable time base of, say, 10 years.

Finally I want to mention that from the uvby photometry of the F dwarfs in the clusters one also derives the m_1 index, which is a very good measure of the abundance of the iron peak elements (Nissen and Gustafsson, Astronomical Papers dedicated to Bengt Strömgren, Copenhagen University Observatory, p. 43, 1978). Thus it is clear that we get some important information on the chemical evolution of the galaxy already from the preparatory part of the programme. So—VLT or not—there is a good reason to strengthen our research on open clusters.

Speckle Interferometry

A. Labeyrie

Radio astronomers have for many years employed interferometric techniques to resolve the finest details in celestial radio sources. One of the first to use similar methods in optical astronomy was Dr. Antoine Labeyrie who is now constructing an interferometric optical telescope at the CERGA Observatory, near Nice in France. He sees the VLT as an array of 2–4-metre telescopes which deliver coherent light beams to a central "coudé" laboratory. With this instrument Dr. Labeyrie hopes to study the surfaces of individual stars and binary systems. It may even be possible to resolve optically the nearest quasars.

Building giant eyes is perhaps part of the normal evolutionary fate for advanced civilizations. Eye size must be a measure of how advanced the civilization is.

At this time, the main technical problem for a 25-metre equivalent telescope is to decrease the cost per square metre for mirror elements of astronomical quality. Two approaches are currently investigated, namely replication and diamond turning, and these promise considerable gains over traditional mirror figuring techniques.

Thus, the problem of what to observe with giant telescopes is certainly relevant at this time. However, in the same way as the builders of Palomar could not prophesy that their telescope would spend most of its time looking at QSO's, the extrapolations made at this time will prove obsolete as new types of mysterious objects are discovered.

The Multi-element Telescope

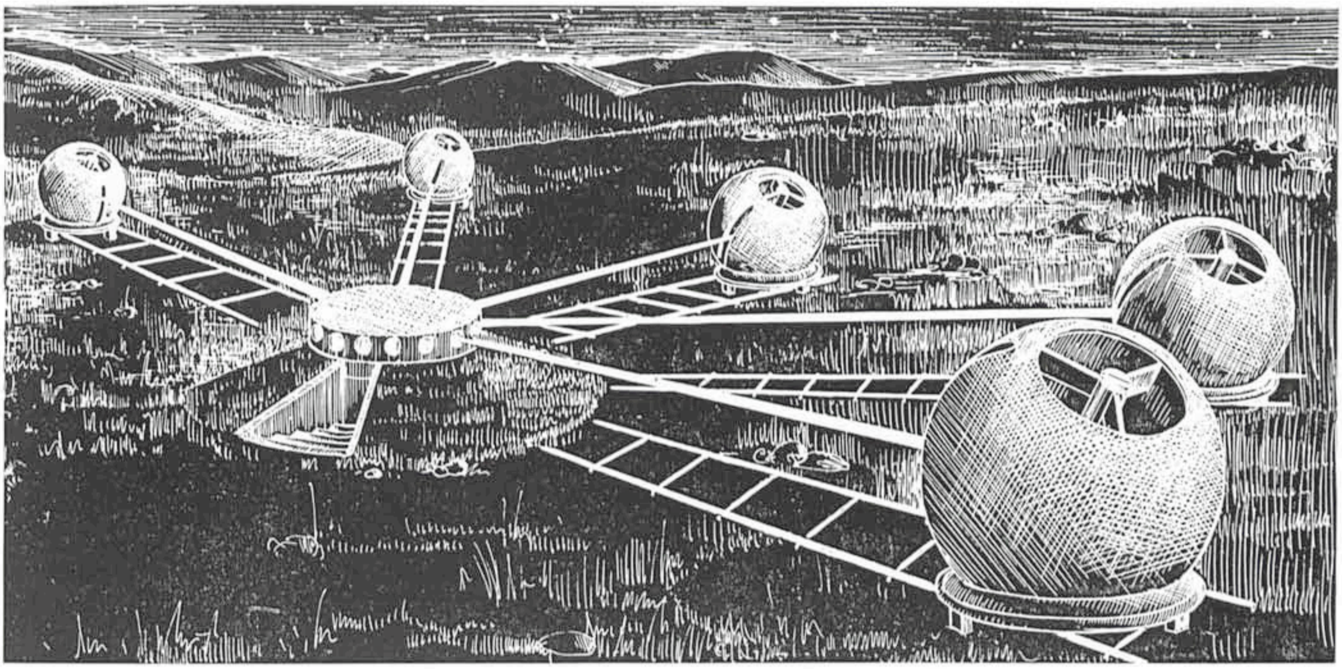
I deliberately assume that the telescope is *coherent*. There is so much more science to do, for a negligible cost increase, with a coherent telescope that I simply cannot imagine any advantage in favour of a non-coherent machine. Achieving coherence is simply a matter of adding micrometric drives, under micro-computer control, and this is now a simple and well-established technique.

Then, let us think in terms of a coherent array incorporating many telescopes. 150 2-metre or 36 4-metre mirrors are equivalent in luminosity to a 25-metre dish, but the resolution can be far superior with a "diluted" array spanning up to several hundred metres. The figure below shows my preferred configuration, the simplest, having a minimum number of coudé flats, and most compatible with future extension and modifications. Coherence only implies that the component telescopes are driven slowly along their radial tracks during observations. As explained elsewhere (1), the ring has to be elliptical with variable eccentricity. In the central laboratory, all the coudé beams converge into a single image. Observable stellar details range in size from 20 down to perhaps 0.1 millisecond of arc.

It is likely that active-optics devices (2) will be available for diffraction-limited images, but only on bright objects.

Resolving the Stars

Now, what shall we observe? The first obvious thing is nearby stars, of which maps can be made. This shows limb-



darkening, certain bright coronas, star spots, stellar rotation, oblateness. According to the few results of speckle interferometry at Palomar, cool stars appear to be accurately spherical. There must be exceptions, particularly among the fast-rotating hot stars. Features resembling Saturn's rings are expected around Be stars, but these were not resolved at Palomar. Are there dots or channels on Betelgeuse, Antarès and Aldebaran? Are Mira stars changing their size or shape as they pulsate? How about observing the pulsations of Cepheids?

Close binaries provide inexhaustible supplies of spectacular observations. How much atmosphere is there between Algol A and B? Accurate stellar masses can be obtained in many cases from observed orbits and radial velocities.

A major gain of information arises from the fact that spectra will become sharper. This is a consequence of improved spatial resolution: In conventional spectrographs the mixing of spectral features produced by different regions of the star widens the observed line profiles. The kind of highly informative spectral and spatial data heretofore obtained on the sun, including spectroheliograms showing detailed atmospheric motions, will also be obtained on the 30 or 100 largest stars. This means nightmares for model-atmosphere experts, and headaches for their computers!

Quasars, Pulsars and X-ray Binaries

Active optics cannot cancel atmospheric effects at stellar magnitudes fainter than 10 or 12, but some less appealing interferometric methods still remain applicable down to $m_v = 15$ or more. These methods can answer some critical questions in cosmology. A speckle-interferometer measurement of 3C 273 suggests a source smaller than 0.″020. Something mysterious happens there, and we do not even know how small the source really is. The bright nuclei of many galaxies also deserve a closer look.

Optical pulsars, particularly the Crab object, are of course worth a look even though neutron-star models predict non-resolvable dimensions for the central object. Indeed, nebulosity near the object might exist and exhibit patterns resembling a searchlight beam in clouds.

Among the X-ray emitting binaries which are believed to incorporate a black hole, certain orbital dimensions can be resolved with the instrument. For the detection of circumstellar planets by direct-imaging means, a single space telescope of 2.5-metre size is more likely to succeed than a large ground-based array. This is because the problem is one of scattered light, not resolution. An additional limitation has to do with faint objects of complicated morphology, such as globular clusters or stars in galaxy images: owing to some basic noise effects in interferometry, these objects are also relevant to space telescopes and arrays.

References

1. A. Labeyrie, *Ann. Rev. Astron. Astrophys.* (1978).
2. J. W. Hardy, *Optical Telescopes of the Future,* Proceedings of ESO Conference, p. 455.

Instrumentation Schedule

Following the proposal of the Users Committee, we shall start with this edition of the *Messenger* to publish regularly our time schedule for the major instruments which are being developed at ESO in Geneva. These instruments are constructed for use on the 3.6 m telescope. The target dates indicate the date of "first light". This means that the instruments will have passed at that date the test procedures in Geneva and on La Silla as far as optical-mechanical and electronical tests are concerned. "First light" is the date of the first trial on the sky. It should be understood that it will take half a year more before the instrument goes into regular use.

It can be assumed as a normal rule that the instruments have a half-year assembly and test period in Geneva followed by a three-month period for shipment and installation before the target date. The detail design gets frozen already one year and a half before the target date.

In order to learn more about these instruments, questions and proposals may be addressed to the astronomer or to the engineer indicated in brackets. For some of the instruments, a description can also be found in the *Messenger* as indicated.

Triplet Adaptor (M. Tarenghi, M. Ziebell). Target date: May 1979. The components are:
- two 3-lens correctors for prime focus
- an adaptor with tv for acquisition and guiding
- a remote-controlled shutter and changer for 4 filters
- a remote-controlled changer for 8 plates (3 magazines); plate size is 240 x 240 mm.

More details will be published in the next *Messenger.*

4 cm Mc Mullan Camera (W. Richter). Target date: October 1979.
- Electronographic camera as developed by Mc Mullan. Can be used behind triplet adaptor in prime focus.

Coudé Echelle Scanner (CES) (D. Enard, J. Melnick). Target date: end 1979.
- Instrument to record very high resolution digital spectra (up to 100,000) on a 1876-channel-DIGICON detector. Double-pass scanning mode permitting calibrations on bright objects with very clean instrumental profile.

For more details see *Messenger* No. 11.

Infrared Top-End (R. Grip, P. Salinari). Target date: start 1980.
- Wobbling secondary mirror with f/35 in Cassegrain focus, new telescope top-ring which puts radiating material away from light beam.

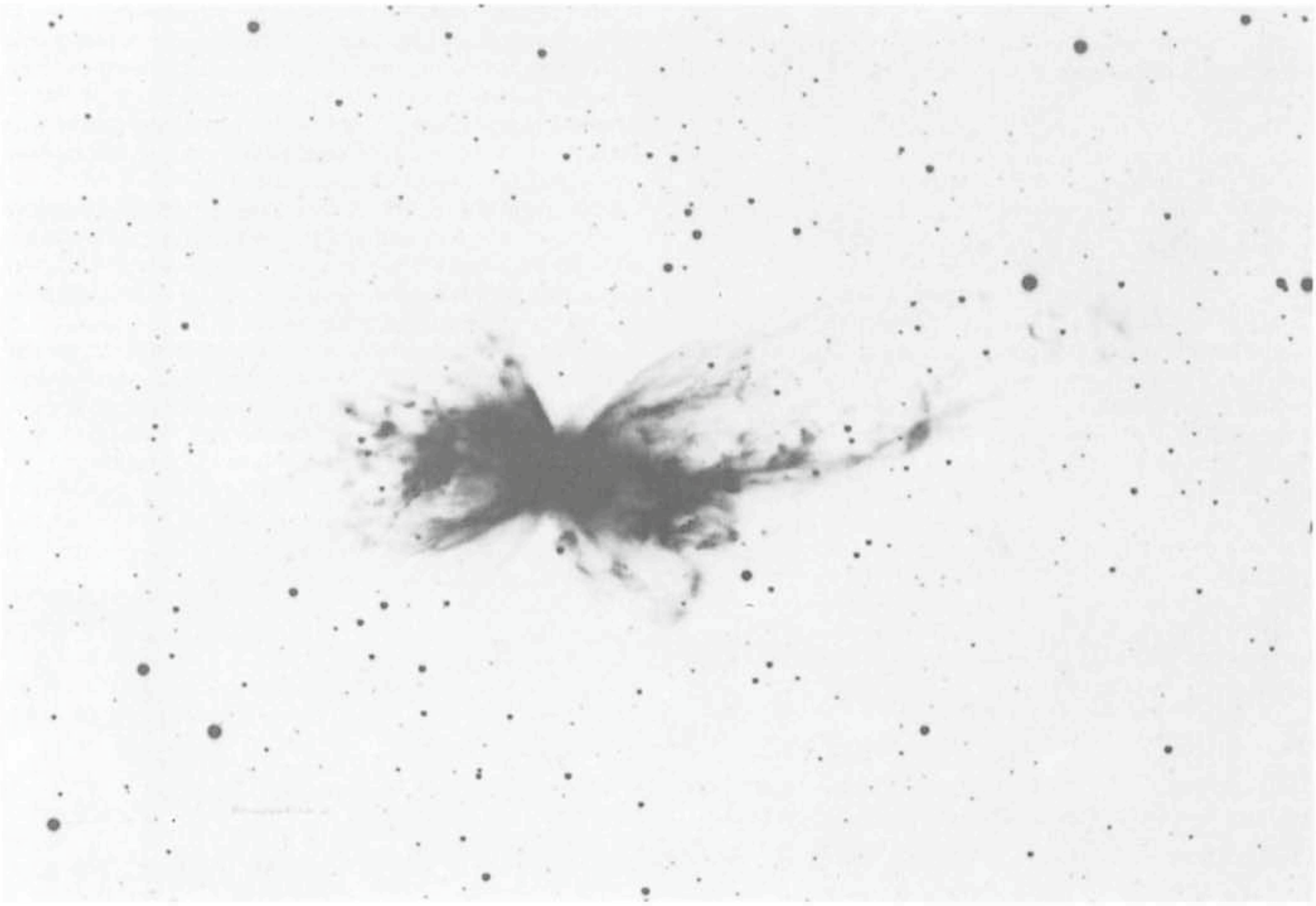
For more details see *Messenger* No. 13.

Coudé Auxiliary Telescope (CAT) (T. Andersen, M. Dennefeld). Target date: mid 1980.
- 1.5 m spectroscopic telescope feeding CES of the 3.6 m telescope. Three-mirror alt-alt telescope with f/120 (f/32 after focal reducer). Dall-Kirkham optics with spherical secondary. Direct drive servos without gear.

For more details see *Messenger* No. 10.

Cassegrain Echelle Spectrograph (CASPEC) (M. le Luyer, M. Ulrich). Target date: end 1980.
- Instrument with resolution of 15,000, 30,000 and 60,000 with an SEC-Vidicon detector. Data-reduction process not yet defined in detail.

W. Richter



Planetary nebula NGC 6302, photographed in red light with the 3.6 m telescope (IIIa-F + RG 630, 20 min; observer: S. Laustsen).

Planetary Nebulae and Comets

L. Kohoutek

Dr. Luboš Kohoutek from the Hamburg Observatory, FRG, is well known, both for his devotion to planetary nebulae and his many comet discoveries. Not quite unexpectedly, he decided to divide his ten nights on the VLT between these two types of objects, expecting to learn more about the processes that lead to the formation of planetary nebulae and the true nature of comet nuclei.

Although the greatest amount of progress at the VLT will probably be made in extragalactic astronomy, the galactic research should not fall into oblivion. Particularly the study of both the early and the late stages of stellar evolution requires special effort, because our knowledge of this fundamental topic has still many gaps.

The theory describing the evolution of red giants in the mass range of 1 to 3 $M_\odot$ into hot white dwarfs through the planetary-nebula stage is generally accepted. Nevertheless, there are many unanswered or only partially answered questions concerning planetary nebulae (PN), mainly: What are the progenitors of PN? What is the physical mechanism responsible for the ejection of PN? Are multiple shells of PN a typical or only an exceptional behaviour? Which role does dust play in PN? Is the distinction of PN in objects belonging to the galactic Population I and II significant and if yes, how is the evolution of these two different groups of planetaries? Why do central stars exhibit a large variety of spectra? Do all stars with low mass become PN?

In my opinion the VLT could contribute very substantially to the solution of these problems, assuming that this telescope would reach a limiting magnitude of about 27 mag, and that it would be equipped with advanced auxiliary instrumentation. Spectrophotometry with non-photographic recording systems, panoramic photodetectors that digitally record line intensities over the whole nebula and multicolour photoelectric photometry in the visual as well as in the infrared region would be the most promising.

The following programmes may be proposed for the ten nights at the VLT:

(1) Protoplanetary nebulae. Detailed investigation of some candidates with the aim of obtaining the basic physical parameters of the exciting stars (temperature, luminosity, radius, surface gravity, mass) and of the nebular envelopes (electron temperature and density, total mass, abundances, expansion velocity).

(2) Selected planetaries with unusual characteristics. Study of individual objects which are important for answering the questions given above: for instance nebulae having unusual morphology (multiple envelopes—e. g. NGC 6543; filaments and condensations—NGC 7293; bipolar structure—M 2-9) and unusual central stars (binary and variable stars—UU Sge, FG Sge, NGC 3132, etc.; stars of extremely low luminosities; nuclei not yet detected—NGC 6302).

(3) Planetary nebulae in LMC and SMC. New data would be used to locate the planetary nuclei in the H.-R. diagram and to improve our knowledge on the evolutionary sequence of PN. Stars of low luminosities (up to $M_V \approx 8^m$) will be detected. The space density and the local birth rate of PN in the Clouds could be determined. This programme would be time-consuming and could only be started during the first ten nights at the VLT.

Very important programmes could also be prepared on objects of the solar system, especially on comets. I would probably save one or two nights of the allotted observing time for measuring **comets at very large distances from the sun.** Spectroscopic and photometric observations of the behaviour of cometary emissions beyond 3 A.U. as well as of the continuum at distances up to 20–30 A.U. would be essential for understanding the nature of these bodies.

To plan observations is as easy as it is difficult to plan discoveries. I am sure that not only better and more accurate observational data, but also many unexpected results and discoveries will be obtained with the VLT.

Observations of High Redshift QSO's

J.P. Swings and J. Surdej

Time-consuming observations with existing large telescopes have shown that the spectra of quasi-stellar objects are exceedingly complex. A VLT is needed to obtain the highest spectral resolution and to study in detail the numerous absorption lines. Drs. Jean-Pierre Swings (Institut d'Astrophysique in Liège, Belgium) and Jean Surdej (ESO) would like to use their nights to investigate the nature of some of the most distant objects in the universe.

Spectroscopic observations of a large number of quasars reveal absorption lines whose redshift is smaller than that measured for the emission lines. This observational fact leads to the question as to whether the absorptions originate in material at cosmological distances (cosmological hypothesis) or are associated with matter initially expelled from the quasar itself (intrinsic hypothesis). It also appears that the richness of the absorption spectrum of QSO's increases markedly above redshifts $Z_{em} \simeq 2.2$ so that these objects have exceedingly complex spectra. It is as if there were a threshold for the presence of absorbing material at redshifts $Z_{em} > 2$. Only a VLT would enable one to survey a homogeneous sample of such faint quasars in a reasonable amount of time and with a sufficiently high resolution. Indeed, the absorption lines in QSO's normally appear sharp at the instrumental resolution and strong features tend to split up into multiple, discrete components with an increasing resolution. For some of the brightest QSO's observed so far, resonance doublet absorption lines have turned out to have multiple components corresponding to velocity shifts of a few tens up to a thousand km/sec. The limiting sharpness of these absorption components will probably be reached when using a high resolving power spectrograph which requires a very large light collector.

Strong arguments in favour of the intrinsic hypothesis are given by the observations of P-Cygni line profiles in high redshift QSO's such as PHL 5200, RS 23, etc. For these QSO's the resonance lines of C IV, Si IV, N V, Lyα, . . . exhibit profiles which may be interpreted in terms of a spherical envelope decelerated by the gravitational field due to the QSO's core. In turn, this enables the determination of important physical parameters such as the mass of the QSO's core. The intrinsic hypothesis is also supported by noticing that for some quasars the absorption and emission redshifts are correlated via a function depending on atomic data (e.g. line wavelength, continuum wavelength). The mechanism ("line-locking") leading to such a configuration of redshifts is the following: matter radiatively expelled from the QSO's surface is accelerated until there is a drop in the continuum it absorbs, because of Doppler shifts. This drop in the continuum may be due to a continuum edge or to the presence of a strong absorption line of another ion. Finally this causes the ejected matter to be stabilized at some discrete velocities. High resolution spectroscopy achievable with a VLT would allow to study many more cases supporting this mechanism of intrinsic origin.

Repeated observations should be performed to search for variability of the absorption features which would provide further arguments in favour of the intrinsic hypothesis. In addition, if the absorption lines are formed in material close to the quasar, then the excited fine structure states will be populated and the corresponding lines would become detectable.

The large photon-collecting capability of a VLT should also be used for observing occultations of QSO's in order to attempt to detect the presence of Lyα circum-quasi-stellar halos predicted in the intrinsic hypothesis and to determine velocity fields, excitation distribution, etc. in the case of QSO's whose spectra show P-Cygni line profiles.

Comets Galore!

A rarely seen burst in comet discoveries occurred between September 1 and October 11, 1978. The final score Amateurs vrs. Professionals must have strengthened the morale of the former: 5 to 1!

It started on September 1, when J. da Silva Campos in South Africa and T. Haneda in Japan independently discovered the same comet, now named Haneda-Campos (1978 j). The comet moves in an elliptical orbit with a period of only 6 years, possibly because it came near Jupiter in 1957 and 1969 and was "captured". Searching the plate archives in Pasadena and Geneva brought to light two prediscovery images of 1978 j from early August, the first with the Palomar 46 cm Schmidt telescope, the second with the ESO Schmidt (see the photo). Blame to the professionals!

Fig. 1: *Prediscovery image of Comet Haneda-Campos on August 9, 1978. ESO 1 m Schmidt telescope. IIa-O + GG 385, 60 min. Magnitude about 12.*

After Comet Giclas (1978 k) found at Lowell Observatory in Arizona, USA, on September 8, followed Comet Machholz (1978 l) on the 13th. It was discovered just before full moon by a California amateur, Don E. Machholz. The ESO plate shown here was the first confirmation from an observatory and was made under difficult conditions.

Then followed Comet Seargent (1978 m) (D.A.J. Seargent, Australia), Comet Fujikawa (1978 n) (S. Fujikawa, Japan) and Comet Bradfield (1978 o) (W.A. Bradfield, Australia) on October 2, 10 and 11, respectively. All three were caught when they were relatively near their perihelia and are now fading.

At La Silla, observations are being planned of Comet Meier (1978 f) when it reaches perihelion on November 11. At that date it will be very low in the morning sky, just above the eastern horizon. The observations will be made at the request of radio astronomers in Europe and USA, who have been tracking Comet Meier during the summer when it was too near to the Sun to be observed optically (see also the article about Comet 1978 c in the *Messenger* No. 13, p. 8).

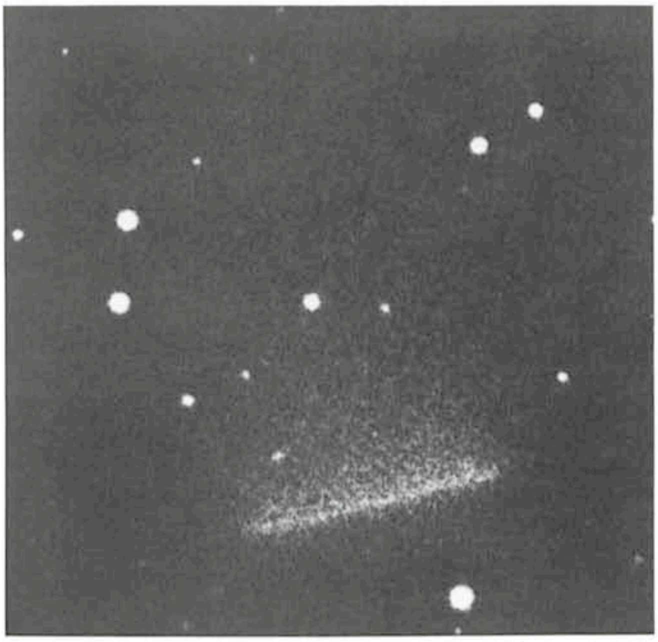


Fig. 2: *Comet Haneda-Campos photographed on September 29, 1978 with the ESO Schmidt telescope when it was just over 24 million kilometres from the Earth.*

Fig. 3: *Comet Machholz on September 14, 1978, photographed with the ESO Schmidt telescope on a 098-04 (red) plate behind a RG 630 filter. Exposure time 10 min in moonlight. Observer: H.-E. Schuster. The horizontal "bars" connected to the brighter stars were caused by a shutter failure.*

UP THERE AND DOWN HERE

WHO used pure hydrogen to hypersensitize the plates?

. . . à partir du sol et c'est pourquoi un colloque organisé par l'ESO (European Space Organisation) . . .

Editorial, *l'Astronomie,* **92,** p. 339 (September 1978).

A Photometric Study of the Bright Cloud B in Sagittarius: First Results

A. Terzan and A. Bernard

During the past years, Drs. Agop Terzan and Alain Bernard of the Lyon Observatory, France, have been studying Schmidt plates of fields in the direction of the galactic centre. Most of the plates come from the ESO Schmidt telescope and a thorough intercomparison of plates in different colours and from different epochs have revealed a large number of new variable stars. Some stars have been found to possess large proper motions and some diffuse objects (galaxies, planetaries, nebulae?) were also discovered.

In *Messenger* No. 10 (September 1977) we informed the readers about our study of a region near the centre of the Galaxy. Our investigation was based on photographic plates obtained with the ESO Schmidt telescope and from the Observatoire de Haute-Provence and Mount Palomar.

Photoelectric measurements in the standard UBV system were obtained in June 1978 at La Silla and we here give some new results pertaining to our study of variable stars in the direction of the Milky Way centre.

The Photographic Plates

To start with, we have restricted ourselves to a 5 x 5° field centred on the bright star 45 Oph. We have compared plates taken in 1976 and 1977 with the ESO Schmidt telescope with plates from the 48 inch Mount Palomar Schmidt telescope which were taken in 1968 by A. Terzan.

As a first result we have so far found 268 variable stars with an amplitude of at least $0\overset{\text{m}}{.}5$. Most of these stars are long-period red variables, probably of the Mira-Ceti type. We have determined their positions, i. e. (X, Y) and (α, δ) with the ESO S-3000 measuring machine in Geneva. In addition, approximately 150 other stars are suspected of being variable. We have just received some further ESO plates which will be used to look into this question.

We have discovered three diffuse objects, the nature of which is still uncertain (fig. 1).

Objects No. 1 and 2 have a constant density over a circular area (with diameter 6–7" and 5–6", respectively) and the density falls rapidly off outside this area. The objects are well visible on V (visual) and R (red) plates which were exposed 15 min and they may just be seen on B (blue) plates exposed for more than 40 min. They are not visible on 60 min UV (ultraviolet) plates. During the photometric run in June with the 1 m photometric telescope on La Silla, A. Bernard was able to measure object No. 1 and he found (within a 16" circular diaphragm):

$$V_{16''} = 17.1 \pm 0.2, \quad B-V = 1.80 \pm 0.06$$

It is therefore reasonable to believe that these objects are rather heavily reddened, due to the high interstellar absorption in this direction. The total visual absorption is probably larger than 3^{m}. The objects may also be intrinsically red, and they could be similar to the compact globular clusters

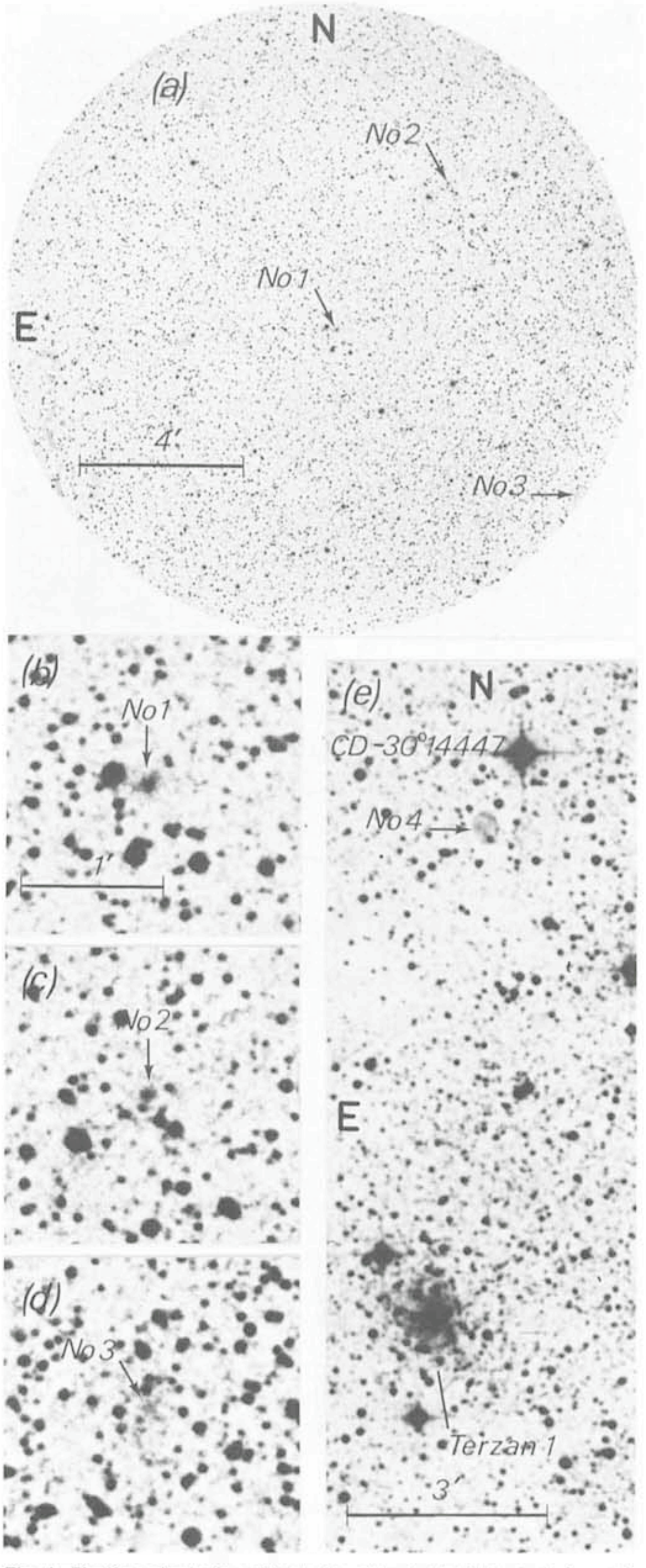


Fig. 1: *Finding charts for objects No. 1 to 4. (a): Objects 1, 2 and 3 on plate No. 1745 obtained in the prime focus of the ESO 3.6 m telescope. IIIa-F baked + RG 630; 60 min; observer: C. Bareau. (b), (c), (d) and (e): Enlargements from ESO Schmidt plate No. 2268. 0.98.04 + RG 630; 30 min; observer: H.-E. Schuster.*

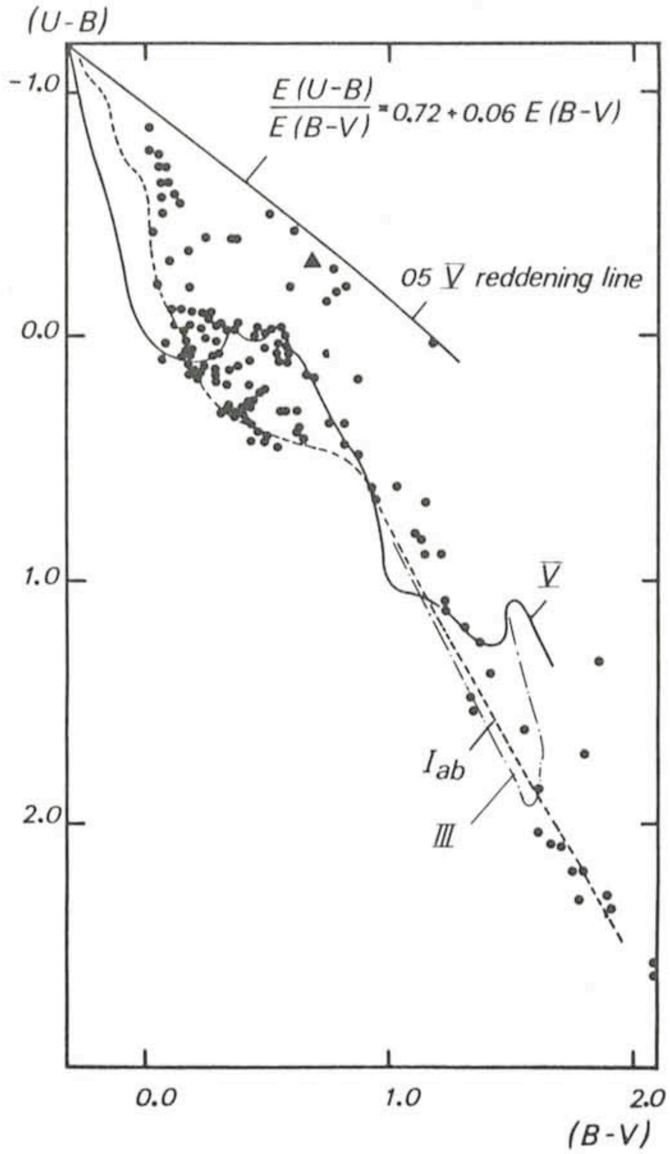


Fig. 2: *Two-colour diagram of 153 stars in a field near 45 Oph. (▲) refers to the star CD −29°13809 which was also studied by Hiltner (V = 9.74; B-V = 0.68; U-B = −0.34; 09 V).*

Liller 1 and Terzan 2, which is also an X-ray source (XB–1724-31). In that case we only see the core of the clusters.

Another object, No. 3 in figure 1, is rather diffuse and is only visible on the R and V plates. It has a circular form with a diameter of 10″ and a soft density distribution.

We have also found a planetary nebula (No. 4) which is situated between the globular cluster Terzan 1 and the star CD −30°14447. It is only seen on the R plate (because of strong emission in Hα) and has a somewhat elliptical form with the major axis oriented NE-SW. There are a number of condensations on the periphery. The central star cannot be seen, even on a 40-min blue plate that reaches beyond 20^m.

A by-product of the present investigation has been the discovery of 21 stars with large proper motions. Five of these have already been catalogued by Luyten in 1957 as having an annual proper motion larger than 0″.2 and a further one was discovered in 1965 by A. Terzan. We envisage to measure the proper motions in collaboration with Dr. A. Fresneau from the Strasbourg Observatory, who is a specialist in this matter.

Photoelectric Photometry

We used the 61 cm Bochum telescope on La Silla to obtain photoelectric photometry in the UBV system of 153 comparatively bright stars. Most of these were measured twice and we were able to establish a UBV standard sequence near 45 Oph, in the following magnitude intervals:

$6.71 < V < 12.04$; $7.05 < B < 12.75$; $6.20 < U < 14.06$

We hope to extend this sequence to fainter stars in the future.

Figure 2 shows the distribution of the stars in a two-colour diagram. We note that giant M stars were observed which are little reddened. They are therefore nearer than 1 kpc. On the contrary, the reddening of most of the observed early-type stars (O5–B0) is larger than 3^m in the visual. They are probably distant stars similar to the group of OB stars observed by Hiltner (Ap. J., 1954, **120,** 41) at a distance of 3 kpc and are probably associated with the spiral arm inside the arm at 1.4 kpc. However, for a detailed determination of the interstellar absorption as a function of distance in our field, it is necessary to measure more stars and, if possible, to define the intrinsic value of the Hβ index of the O stars.

Further photoelectric measurements were obtained with the ESO 1 m telescope. About 50 stars, situated within 10′ of the open cluster Trumpler 26, were measured in UBV (this cluster is 23′ NE of 45 Oph). The aim of this investigation is to learn the structure of the absorption in this direction and to study the cluster itself. Somewhat unexpectedly, the resulting two-colour diagram (fig. 3) does not indicate the ex-

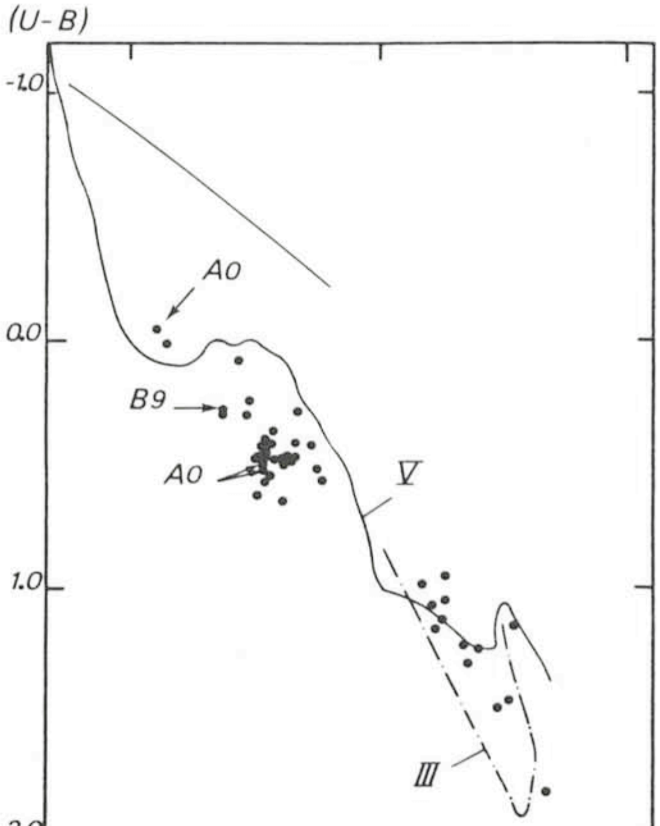


Fig. 3: *Two-colour diagram of 46 stars in the field of the open cluster Trumpler 26.*

istence of a physical group of stars. We still need additional information about the luminosity classes to resolve this problem. We should also like to add that we have determined m_r and m_{ir} of 274 stars in this field by means of photographic observations at Observatoire de Haute-Provence.

Future Work

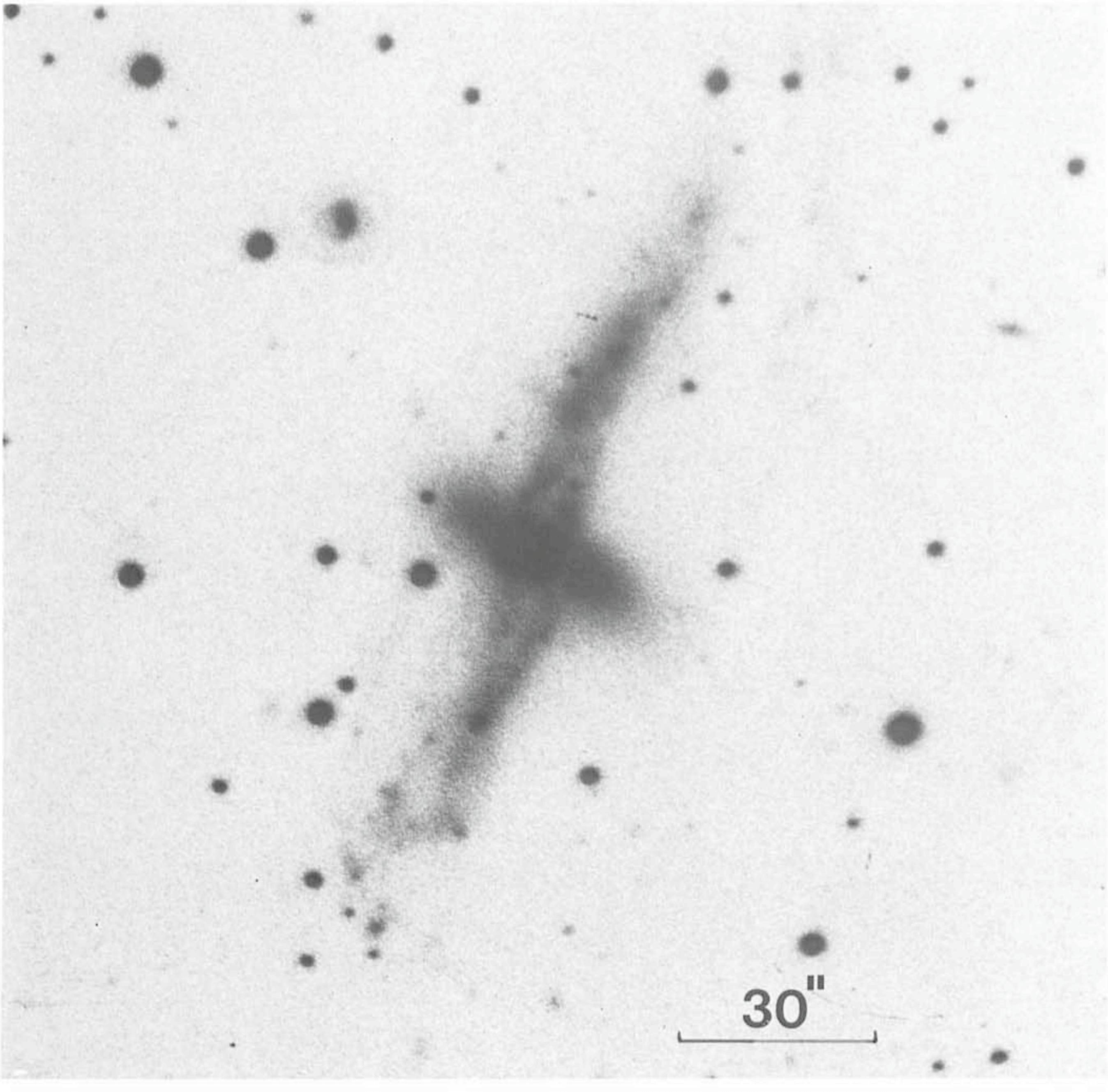
There is obviously much work still to be done in order to terminate the present study. First of all, we expect to determine the types of the 268 variable stars by means of further plates from the ESO Schmidt and to construct the light curves. Secondly, we should like to confirm (or disprove) the variability of the 150 suspected candidates.

We also intend to study spectroscopically the above-mentioned three diffuse objects and to measure the radial velocities and UBVR magnitudes of the 21 stars with large proper motions. We finally expect to continue the photoelectric photometry of many other stars in the direction of the bright cloud B in Sagittarius.

We should like to thank Prof. L. Woltjer and Dr. A. B. Muller for their encouragement and the continued interest they have shown in our work.

The Peculiar Galaxy NGC 4650 A

In the western part of the constellation Centaurus lies a spectacular chain of galaxies. Some of the members are elliptical, others are spiral, and one is very peculiar. Its name is NGC 4650 A and the integrated magnitude is about 14^m. The



galaxy chain is shown in Sersic's atlas *Galaxias Australes* and he also made a preliminary spectroscopic study (*Astrophys. Space Science,* 1972, **19,** 387).

Improved photographic and spectroscopic observations have now been obtained with the 3.6 m telescope by ESO astronomers S. Laustsen (now at the Aarhus Observatory in Denmark) and R. M. West. The figure shows a 90-minute exposure in prime focus on IIIa-J emulsion behind a GG 385 filter. It appears that the galaxy consists of a central elliptical component, surrounded by a disk (?), perpendicular to the major axis of the ellipsoid. A heavy dust band is seen where the disk component shrouds the light from the elliptical. Many knots are in the disk, north and south of the central region.

The spectra show that the knots are low-excitation H II regions (ionized hydrogen) and that the disk apparently is rotating. The northernmost knots have velocities of about $+120 \text{ km s}^{-1}$ and the southern -90 km s^{-1}, relative to the centrum. The spectrum of the elliptical component is of late stellar type, indicating that it consists mainly of stars. Contrarily most of the disk is made of gas and dust.

The distance to NGC 4650 A is about 50 Mpc and its N-S diameter is almost 40 kpc (projected).

There are a number of other galaxies that are morphologically somewhat similar to NGC 4650 A, although the individual shapes may vary significantly. Among these are several radio sources, like NGC 5128 (Cen A) and Cyg. A. Two Italian astronomers, Drs. F. Bertola and G. Galletta from the Asiago Observatory have recently begun a detailed study of these galaxies. They believe that they are all members of the same class of galaxies that has a prolate stellar structure cut equatorially by a gaseous plane. The dynamical behaviour of these systems is complicated and is not yet understood.

The Story of Minor Planet (2100) RA-SHALOM

The number of known Apollo-type minor planets has risen dramatically during the past years, mainly as a result of the great observational efforts by Californian astronomers. Two of these stand out as the discoverers of particularly interesting objects: Eleanor F. Helin and Charles T. Kowal of the California Institute of Technology in Pasadena. Working with the 46 cm and 122 cm (48 inch) Schmidt telescopes on the Palomar mountain, they regularly find new, peculiar minor planets.

Three years ago, Mrs. Helin discovered the first minor planet with an orbit *smaller* than that of the Earth. The planet, 1976 AA, was named after an Egyptian sun-god, ATEN. Soon after, yet another planet was found to have a similar orbit, lying mostly inside the Earth's orbit (1976 UA, cf. *Messenger* No. 7, p. 5). And now, in September 1978, Mrs. Helin found a third, 1978 RA. It has been proposed that these three should be called "Aten"-asteroids to distinguish them from the other Apollo-asteroids which, although they cross the orbit of the Earth, still have orbital periods of more than one year.

Fig. 1: *The discovery trail of RA-SHALOM, observed with the Palomar 46 cm Schmidt telescope on September 10, 1978.*

Fig. 2: *A follow-up observation of RA-SHALOM with the ESO Schmidt telescope on September 22, 1978. The trail is somewhat wiggly due to (insufficient) guiding. Exposure 30 min under very bad seeing conditions.*

1978 RA was discovered on September 10, 1978 with the Palomar 46 cm Schmidt telescope, on a IIa-D film, exposed for 20 minutes (see the photo). Further observations were made during the following nights and it soon became clear that the orbit was unusual. Then, on September 14, Dr. J. G. Williams, from the Jet Propulsion Laboratory, also in

Pasadena, had the good idea to search the literature for possible, earlier observations of 1978 RA. He was able to demonstrate that 1978 RA was identical with minor planet 1975 TB, which was found by R. M. West on two ESO Schmidt plates, late in 1975 (photo in *Messenger* No. 6, p. 11). However, at that time, only two plates were available, and the orbit could not be unambiguously determined.

Connecting the 1975 and 1978 positions, it became possible to establish the orbit of 1975 TB = 1978 RA with great precision. It turned out that it has the shortest known period among all asteroids, only 277 days, or very close to 3/4 of a year. It therefore spends most of the time well inside the orbit of the Earth and due to the relatively large eccentricity, 0.43, the perihel is only 70 million kilometres from the Sun, i.e. just outside the Mercury orbit. As a matter of fact, it can only be observed every third year, when it passes "behind" the Earth, as seen from the Sun.

With the prerogative of the discoverer, Mrs. Helin has decided that the new planet shall carry the name RA-SHALOM (the 1975 ESO observations do not count, because the orbit could not be established from only two observations). RA-SHALOM has been numbered (2100) on the MPC (Minor Planets and Comets) Circular 4541 and the name is explained (on MPC 4548) as follows: "Named by the discoverer for the Egyptian Sun-god RA, who symbolizes enlightment and life, and for SHALOM, the traditional hebrew greeting meaning peace. This name is chosen to commemorate the Camp David Mid-east Peace Conference, at which time this unusual body was found. May it stand for a symbol for universal hope for peace."

RA-SHALOM is unique in being the only Apollo- (or Aten-) type planet to have been discovered twice. Interestingly enough, the orbit was calculated in 1975 by Dr. Brian Marsden on the basis of the ESO observations (two long trails, i.e. four trail ends) and he found, among other possible orbits, also the correct one. However, at that time no minor planets were known to have the semi-major axis less than 1 A.U. (or a period less than one year) and that solution was rejected.

Photoelectric observations have been made of RA-SHALOM by Dr. E. Bowell of the Lowell Observatory at Flagstaff, Arizona. They show that it rotates once about every 12 hours and that it could be of carbonaceous composition. It may therefore be related to the very rare type of stony meteorites containing carbon, water and other volatile substances.

With the discovery of the third Aten-type minor planet, it has become clear that there may be a substantial number of minor planets inside the Earth's orbit. Attempts have been made to look for them by observing close to the Sun, but so far none has been found that way.

The ESO Finance Committee on La Silla

After seven years the ESO Finance Committee once again met for a regular meeting on La Silla.

Mr. Deloz (Belgium), its Chairman, and Mr. Grage (Denmark), Mr. Rey (France), Dr. Sandtner (Germany), Mr. van Welt (Holland), Dr. Ottosson (Sweden) arrived in Santiago during the weekend of November 4/5, 1978. On November 5 the official programme began with a welcome reception in ESO's Guesthouse in Santiago, offered by Prof. Woltjer, in honour of the delegates. Santiago staff, both international and local, were also invited.

On November 6, the guests flew to La Silla and toured the observatory site with all its many new installations. The morning of November 7 was dedicated to the committee work; in the afternoon the guests departed for La Serena, visiting the town and all ESO properties. Later at night, during an open-air barbecue in ESO's "Office Bungalow" in La Serena, committee members had another opportunity to meet representatives of the international and local staff working on La Silla.

On November 8 they visited AURA Inc. and their Tololo Observatory where the party was warmly received. After another busy morning of committee work they left La Silla in the afternoon of November 9. Some committee members went by car to Santiago in order to have a glimpse of beautiful Chile.

The Director General and his collaborators were happy to have the Committee once again at the observatory. They were pleased about the interest the Committee showed in the new installations and in the general conditions on La Silla. We sincerely hope that our guests liked their stay with ESO in Chile.

I. Meinen

PERSONNEL MOVEMENTS

(A) Staff

ARRIVALS

Garching

Robert FISCHER (French), Head of Contracts and General Services Branch, 1.2.1979.

Geneva

Klaus KLIM (Danish), Electronics Engineer, 1.12.1978.

DEPARTURES

Garching

Johannes VAN TOL (Dutch), Head of Purchasing/Transport Services, 31.12.1978.

(B) Paid Associates – Fellows – Coopérants

ARRIVALS

La Silla (Scientific Group)

Johannes VERMUE (Dutch), Fellow, 15.1.1979.

New Head of Scientific Group in Geneva

Following his appointment as Director of the Arcetri Observatory in Florence, Professor FRANCO PACINI has resigned as Head of the Scientific Group in Geneva as of 31 October 1978. He is succeeded by Professor PER OLOF LINDBLAD from Stockholm Observatory who has taken up his functions on 1 November 1978.

The Image Photon Counting System and Quasars at La Silla

I.J. Danziger and M. de Jonge

August 1978 was a very hectic month on La Silla. Members of the Technical Support Group, under the leadership of Dr. Marius de Jonge, worked around the clock to get everything ready at the 3.6 m Cassegrain focus for two weeks' observations with the Boksenberg Image Photon Counting System. The efforts of the ESO technicians and the visiting astronomers were brilliantly successful and many unique observations were made. Together with other colleagues, Dr. John Danziger (ESO-Geneva) observed a number of faint galaxies and quasars. One of the aims was to study the detailed structure of absorption lines that are seen in many distant quasars and to throw some light on their origin. Are these lines formed in the immediate neighbourhood of the quasar or by intervening matter in intergalactic space?

The Image Photon Counting System

During August and September 1978, the Image Photon Counting System (IPCS) developed at University College London by Dr. A. Boksenberg was installed on the Boller and Chivens spectrograph at the Cassegrain focus of the 3.6 metre telescope. Over a period of more than two weeks, ten different astronomers from Europe and Chile made observations with the system on a variety of different programmes. The IPCS itself was maintained and operated by Dr. Boksenberg and his technical support group consisting of Keith Shortridge and John Fordham. However, the installation of the IPCS on the spectrograph and telescope required considerable extra effort by the Technical Support Group at La Silla. The increased demands for optical, mechanical, and electronic assistance resulted from the introduction of this new instrument to La Silla.

A successful and productive observing period would not have been possible unless members of the Technical Support Group had been prepared to work late into the night preparing equipment and helping to solve unforeseen problems.

It was the greatest support activity ever given to the instrumentation of visiting astronomers. Since the magnetic coil normally used with the IPCS could not be adapted to the Boller and Chivens spectrograph due to the optical and mechanical characteristics of the spectrograph, it was decided that ESO should build a special coil for the experiment. Discussions first began in London in December 1977. ESO provided the mechanical parts of the coil and TV adaptor, and University College did the winding and magnetic field test. After the coil was designed and built in Chile during a three-month period, it was shipped to London for winding at the end of May 1978. Following the necessary work, the wound coil was shipped back to Chile and arrived almost simultaneously with the IPCS electronics which had been shipped from the Hale Observatories in California. It arrived at La Silla some days before the beginning of the observing run. During those few days several last-minute problems had to be solved. Special racks had to be constructed to hold electronic equipment in the Cassegrain cage. An additional machined spacer had to be made to allow correct adaptation of the IPCS module to the camera of the spectrograph. Some temporary rearrangements were required in the control room of the telescope also to provide for convenient observing with the extra control and data-gathering equipment installed there. Figure 1 shows the end result of all of the activity in the Cassegrain cage. One can see the IPCS module attached to the spectrograph on the left, with the control electronic racks in the background.

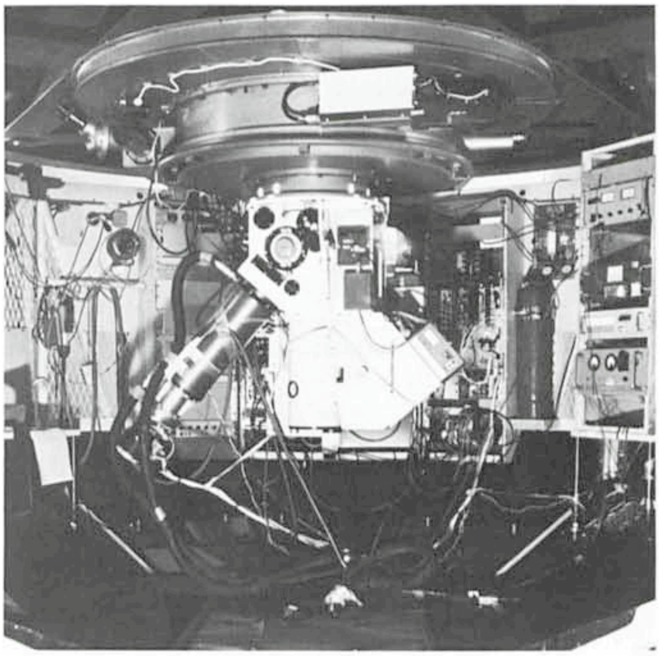


Fig. 1: *A view of the 3.6 m Cassegrain cage with the IPCS equipment installed.*

The IPCS has two important properties that make it extremely useful for working on faint quasars. Individual photons arriving at the detector are recorded as separate events by means of several stages of image-tubes followed by a television camera. In addition, the precise location of each photon event on the photocathode means that when the system is used with a spectrograph, the Boller and Chivens in this case, one can achieve spectral resolutions comparable to those allowed by the optical components of the spectrograph.

These are the properties of a spectrograph-detector system that one requires in order to study narrow absorption lines in distant quasars. During the observing run on the 3.6 metre telescope most programmes were involved with extragalactic astronomy, and some of the results for galaxies will undoubtedly be described at a later time in the *Messenger.* For the moment, we want to explain what was attempted with the observations of quasars, programmes of interest mainly to Boksenberg, Danziger, Fosbury and Goss.

Quasar Absorption Lines, "Intrinsic" or "Cosmological"?

During the past decade there have been known to exist many narrow absorption lines in the spectra of quasars. Due to more intensive studies in recent years it is known that these lines, which occur more frequently in the distant quasars, are much more prodigious in number at wavelengths shortward of Lymann α than at longer wavelengths. Only because one observes distant quasars with large redshifts (probably due to the cosmological expansion of the universe) can one see Lyman α redshifted from a rest wavelength of 1215 Å into the optical wavelength region near 4500 Å.

The origin of these absorption lines, i.e. the region in space where they are formed, and the physics of their origin has been a debating point in astronomy during the past decade. There are two main competing schools of thought which we shall call the "intrinsic" and the "cosmological". One school believes that the lines are formed in material that is physically related to the quasar in whose spectra the lines are observed. This material, while being close to the quasars, is hypothesized as matter ejected or expelled from the quasar. The other school of thought believes that they are mostly Lyman α lines formed in intergalactic gas clouds possibly associated with galaxies at large distances, i.e. cosmological distances, from the quasar, but lying in the line-of-sight to the quasar.

Why is it important to clarify which of these ideas is correct? If the first point of view is correct then the study of these absorption lines provides a means of probing the immediate or even partially internal environment of quasars; if the second is correct one has a means, however limited, for studying intergalactic gas, the amount of it, and possibly its chemical composition, both important parameters in the study of cosmology. In principle one ought not to allow preconceived preferences to obscure one's perception of reality. At the risk of seeming to contravene this dictum before discussing further evidence, one could say that the second hypothesis might in the long run be more interesting if true, because at last, one might have a means of probing what hitherto has been observationally a very elusive intergalactic medium. But in addition one will be able to probe intergalactic gas clouds and galactic halos at distances (and therefore ages) that are in cosmological terms significantly different (and younger) than the nearby galaxies.

Since week-long meetings are given to discussing this subject, one can give here only the briefest of summaries concerning the evidence for and against the two theories.

1. It is difficult to understand empirically in the "intrinsic" hypothesis how the absorption lines can have such small velocity dispersions when the indicated velocity of ejection from the quasar is in some cases relativistic. This poses no special problem for the "cosmological" theory since narrow absorption lines have already been found in halos of galaxies.

2. It is claimed that there is a non-random distribution of the absorption line velocities seen in quasars. While the reasons are not explained physically in detail in the "intrinsic" theory, such a phenomenon is difficult to understand in the "cosmological" case. There is not, however, agreement about the reality of this non-randomness, and the debate continues with strong counter-claims of evidence for randomness.

3. There is also a claim for the frequent occurrence of an absorption (and emission) line redshift system at $Z = 1.95$. If it is real it is difficult to understand within the "cosmological" framework.

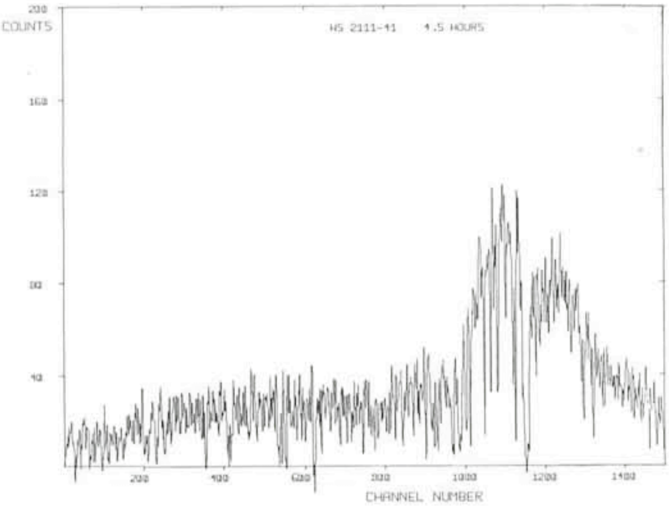


Fig. 2: *A tracing of the spectrum of H-S 2111-41, resulting from 4½ hours observing, with the sky light subtracted. Redshifted Lyman α is the broad emission feature to the right. Narrow absorption lines are seen over most of the spectrum.*

4. Claims for the occurrence of other special wavelength ratios have been interpreted in the "intrinsic" theory as evidence for "line-locking". In principle "line-locking" requires that the expelled gas have absorption line features which, when Doppler-shifted relative to the velocity system of the parent quasar, correspond in wavelength to that of an emission feature, possibly an absorption feature or absorption edge.

While there is no reason to expect this phenomenon in the "cosmological" theory because of the very diffuse radiation fields in intergalactic clouds, it is also theoretically difficult to understand whether there would be sufficient energy to make this a viable mechanism in the "intrinsic" theory. In any case the reality of these special wavelength ratios has been challenged at various times.

5. The absence of absorption lines formed from fine structure levels in ions represents a major problem for the "intrinsic" theory. One might have expected that in the higher radiation fields and/or higher density regions near quasars such fine structure levels would be populated. Their absence poses no problems for the "cosmological" theory since in remote clouds the radiation density and particle density would be low. Indeed even their possible presence in galactic halos would not invalidate the "cosmological" theory, since denser clouds in our own galaxy produce such lines.

6. The presence of H and K Ca II absorption lines seen in the spectrum of the quasar 3C 232, but having the velocity of the bright galaxy NGC 3067 behind whose halo 3C 232 is situated, makes a strong case for the "cosmological" theory. These observations of Boksenberg and Sargent (*Ap.J.* **220,** 42, 1978) and the 21 cm radio line observations in the same region and in other extended galaxies demonstrate that sufficient material exists in the extended halos of normal galaxies to give rise to absorption lines of the type seen in distant quasars.

This does not exhaust all of the evidence and ideas used in the debate on narrow absorption lines in quasars, but it provides a basis and rationale for the IPCS observations made with the 3.6 metre telescope at La Silla.

High-resolution Observations of Faint Quasars

Figure 2 shows a spectrum of the distant quasar Hoag-Smith 2111-41 resulting from 4 ½ hours of integration at a spectral dispersion of 30 Å/mm obtained at La Silla. The ordinate shows real photon counts for each picture element accumulated over the total integration time. Therefore the detected photon arrival rate is on average approximately 10 per picture-element per hour. Having a visual magnitude of 20 this is the faintest quasar ever observed at such a high dispersion.

One can see on the right the broad emission feature of Lyman α redshifted ($Z = 2.64$) to 4420 Å. Most of the sharp absorption lines will be the narrow Lyman α lines discussed above. Note that many of the lines have zero intensity at their centres, indicative of considerable absorbing material in the clouds. The lines in many cases are not resolved which will help put a significant upper limit on their widths.

Spectroscopic material of this quality is relevant to and exemplifies the discussion of items 1, 2, 4 and 5 above. In particular H-S 2111-41 is faint for its redshift, and was chosen because of that. If the "intrinsic" hypothesis is correct, one ought to see differences in the nature of the absorption-line spectrum (velocity distribution and strength of the lines) compared to the spectrum of a quasar with similar redshift but of greater luminosity. There is accumulating evidence that no significant differences exist in such comparisons, and hence the evidence goes against the "intrinsic" idea.

Another important observation at La Silla relevant to item 6 above was the observation of the $17^{m}.5$ quasar PKS 2020-37. It falls near but outside of a foreground galaxy of uncertain (spiral?) type. PKS 2020-37 (redshift $Z = 1.1$) was observed for 5 hours with the IPCS at a spectral dispersion of 30 Å/mm. The H and K Ca II absorption lines which are reasonably narrow, have been detected in the spectrum of the quasar but with the redshift of the nearby galaxy which was determined during the same period.

This supports the results and conclusions discussed as item 6 above, and reinforces the notion that galaxies have extended halos and can contribute to the narrow absorption lines seen in distant quasars. Figure 3 shows a tracing made at the telescope revealing the broad H and K lines in the spectrum of the galaxy and a tracing revealing the narrow lines in the spectrum of the quasar at almost the same wavelength.

Thus, the two observations discussed above serve to exemplify classes of almost limiting astronomical problems that are accessible to European astronomers using the 3.6 metre telescope equipped with a modern detector.

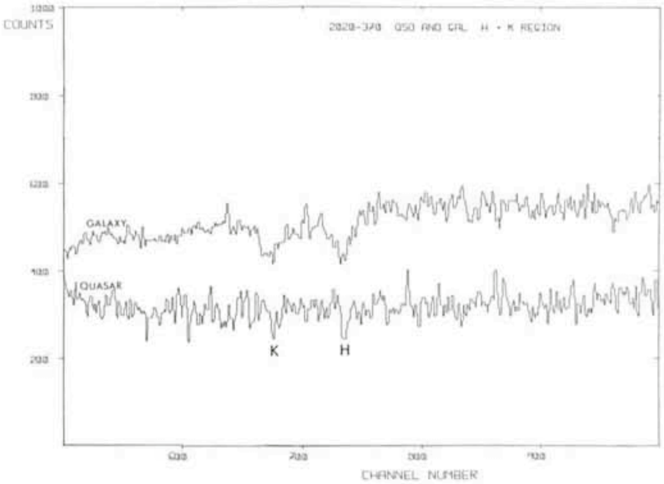


Fig. 3: *The upper tracing is that of the foreground galaxy discussed in the text. One sees stellar (and possibly interstellar) Ca II H and K. The lower tracing is the spectrum of PKS 2020-37 showing interstellar H and K at the same wavelength (or velocity) as the H and K in the galaxy.*

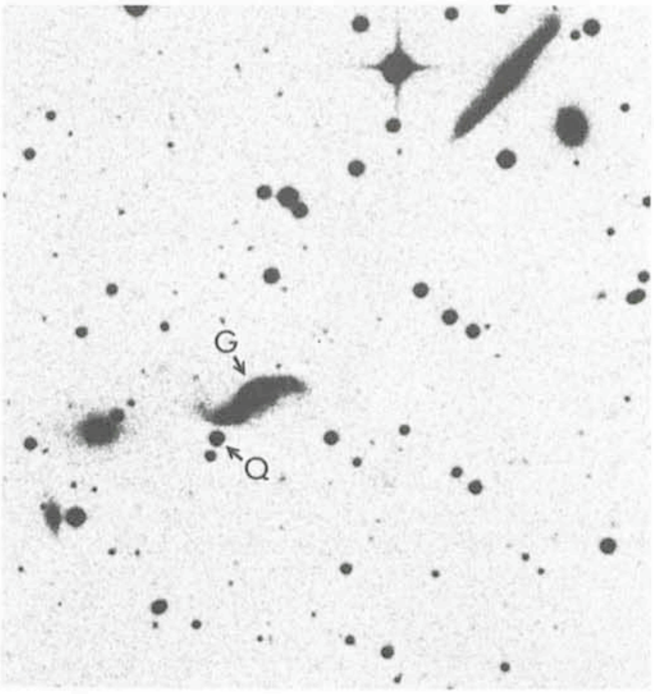


Fig. 4: *A direct photograph of the field of PKS 2020-37 reproduced from a IIIa-J SRC Schmidt survey plate. Arrows indicate the quasar PKS 2020-37 and the nearby galaxy.*

INFORMATION FOR VISITING ASTRONOMERS

Photographic Plate Service on La Silla

Recent analysis covering a period of 18 months has shown that various of the photographic emulsions offered to the visiting astronomers are never requested.

Since offering a photographic emulsion implies regular quality control, renewal of stock, etc., a considerable economy can be realized if emulsions that are never requested and used are suppressed.

As a consequence, only the emulsions listed below will be offered to the visiting astronomers as from January 1, 1979.

IIa-O, IIa-D, IIIa-J, IIIa-F, 103a-D, 098-02, IV-N.

Only for these emulsions will quality control tests be performed and the stock renewed regularly.

The emulsions 103a-E, 103a-F, 103a-G, 103a-O and I-N will only be available as long as the present stock lasts. Quality control tests will not be made any longer for these emulsions.

M. J. de Jonge

Hα Photographs of Southern Galaxies

A number of splendid photographs were recently obtained of selected southern galaxies, in the light of the Hα line (6562 Å), by Drs. Courtès and Boulesteix (*Messenger* No. 14, p. 2). We here reproduce four of these that show an incredible number of H II regions, thanks to the superior resolving power of the 3.6 m telescope.

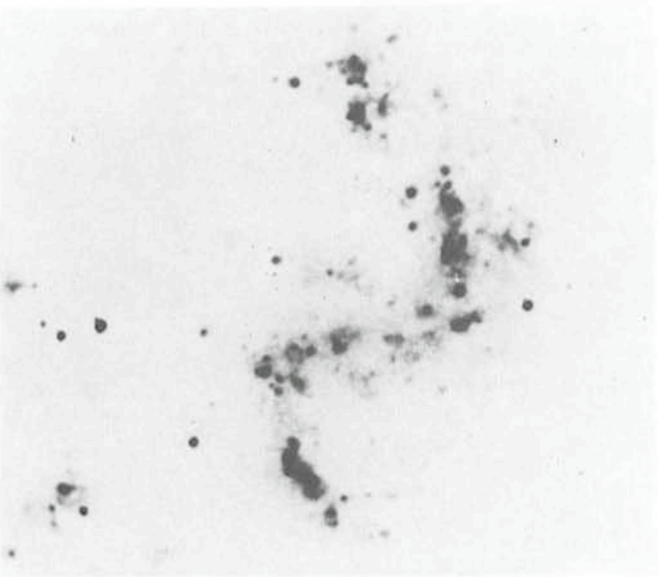


Fig. 1: *NGC 1313, as photographed through a 15 Å wide Hα filter with a focal reducer (f/8 to f/2), RCA two-stage magnetic intensifier and IIIa-J emulsion. This galaxy is a nearby irregular, Magellanic type and the "barred" structure is clearly visible on the photo. Exposure time 15 min.*

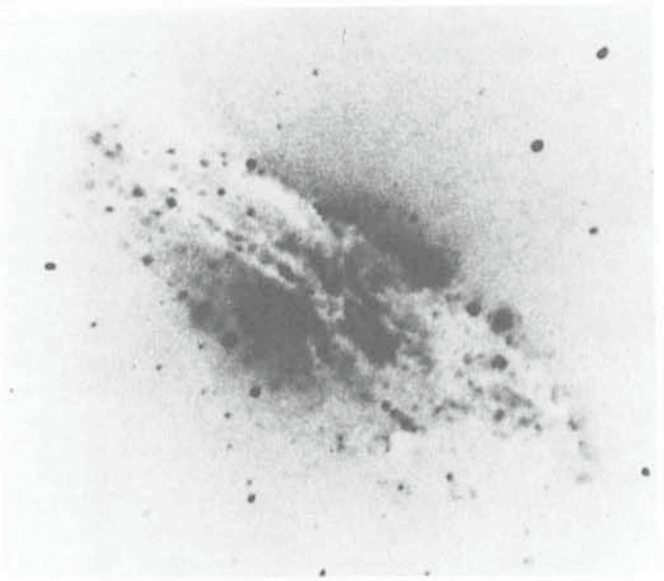


Fig. 3: *Direct Hα photograph of the giant galaxy NGC 5128 (the interferogram was shown on the frontpage of* Messenger *No. 14). Same equipment as NGC 1313. Exposure time 15 min. The giant H II complexes are clearly seen with a very good contrast.*

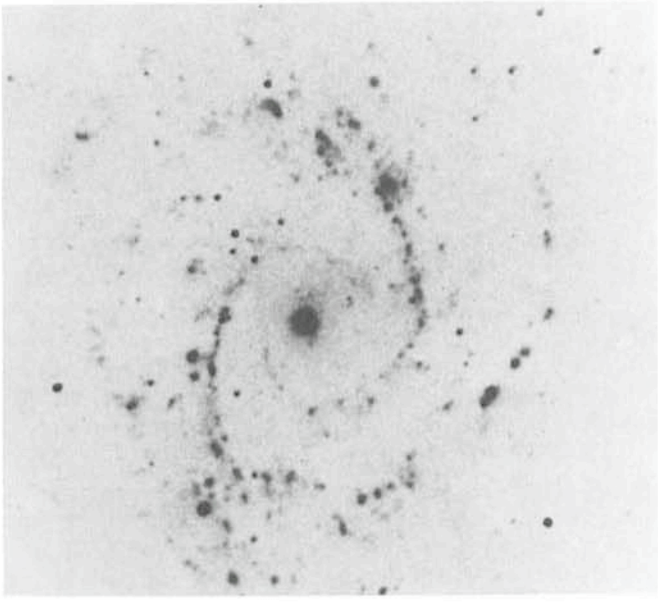


Fig. 2: *NGC 2997 photographed with the same equipment; exposure time 10 min. Note the multiple arm spiral structure.*

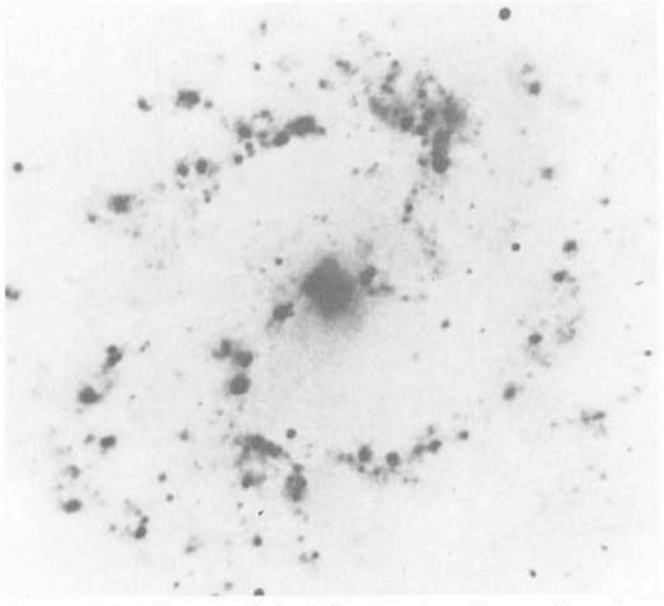


Fig. 4: *NGC 5236 in the light of Hα; 20-min exposure. More than 600 (!) H II regions are detected on this plate.*

NEWS and NOTES

No New Hildas and Thules, but...

In the last issue of the *Messenger* (No. 14), Drs. Schubart and Schmadel from Heidelberg informed us about a search with the ESO Schmidt telescope for "out-of-the-Ecliptic" minor planets. Some plates were obtained early in September 1978 at ecliptical latitude 42° and a total of five interesting minor planets were found. Further plates have made it possible to improve the computed orbits and it now appears that (unfortunately) none are of the types looked for, i.e. Hilda- or Thule-type. Nevertheless, all the five are unusual and all have high orbital inclinations.

1978 PA belongs to the moderately rare Hungaria group, *1978 PC* is most probably of the very rare Phocaea type and

1978 PD may well be of the extremely rare Griqua class (2:1 resonance), but more observations are necessary to confirm this preliminary result. *1978 RB* turned out to be identical with *1974 KA* which was originally discovered by Helin, Smith and Sanders with the Palomar Schmidt. Its orbit can now be determined with excellent accuracy. The fifth object has not yet received an official designation, but has evidently a rather high inclination and a large eccentricity.

Confirmation of the Possible 97-minute Periodicity for the X-ray Binary 4U 1700-37/HD 153919

In the last issue of the *Messenger* (No. 14, p. 8), G. Hammerschlag-Hensberge and E. van den Heuvel (Astronomical Institute of the University of Amsterdam) discussed the possible 97-minute periodicity discovered from *X-ray* pulsations in the X-ray binary 4U 1700-37/HD 153919 by T. Matilski (Rutgers University) and J. Jessen (Massachusetts Institute of Technology) on April 1978.

Though good evidence was reported by A. Kruszewski (Warsaw University Observatory) for the presence of *optical* pulses in the light-curve of 4U 1700-37 and later on by G. Hammerschlag-Hensberge and E. van den Heuvel, the latter concluded that more data were required to definitely confirm the existence of this periodicity.

Kindly adviced by A. Kruszewski and I. Semeniuk (Warsaw University Observatory/ESO), J. Surdej (ESO) observed the star HD 153919 with the 60 cm Bochum telescope at La Silla on June 15, 1978. Broad-band UBV observations and measurements through an interferential filter centered at λ 4686 (He II) were carried out during more than 9 consecutive hours while the binary phase was about 0.5 (X-ray source in front of the companion). The results are shown in figure 1 and figure 2, for the V and He II λ 4686 filters, respectively. Oscillations in the V light-curve of 4U 1700-37 with a period of $95^{\mathrm{m}} \pm 3^{\mathrm{m}}$ ($0\overset{\mathrm{d}}{.}0666 \pm 0\overset{\mathrm{d}}{.}0021$) and an amplitude of 0.01 mag are clearly seen in figure 1. The variations in the narrow-band filter are of similar amplitude (see fig. 2) and show an interesting secondary minimum. The confirmation of the possible 97-minute periodicity first reported by T. Matilski and J. Jessen is now well established.

Combining all X-ray and photometric observations now available, A. Kruszewski noticed that they seem to indicate a decrease for the pulsar period. The rate of this decrease is such that the period may become one order of magnitude shorter during one human life-time!

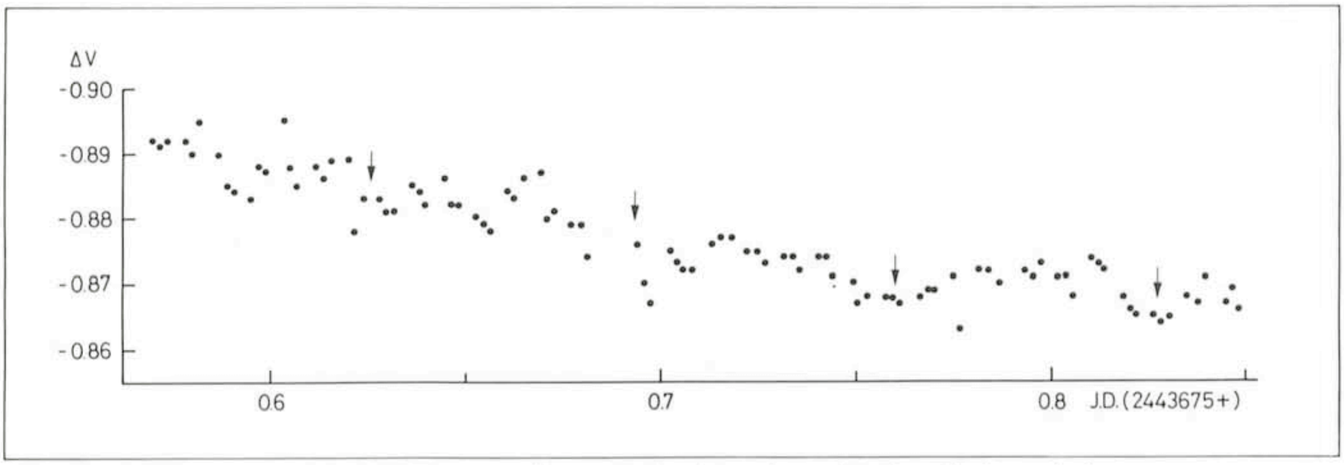


Fig. 1: *The V light-curve of 4U 1700-37. The arrows ↓ separate time intervals equal to the pulsation period.*

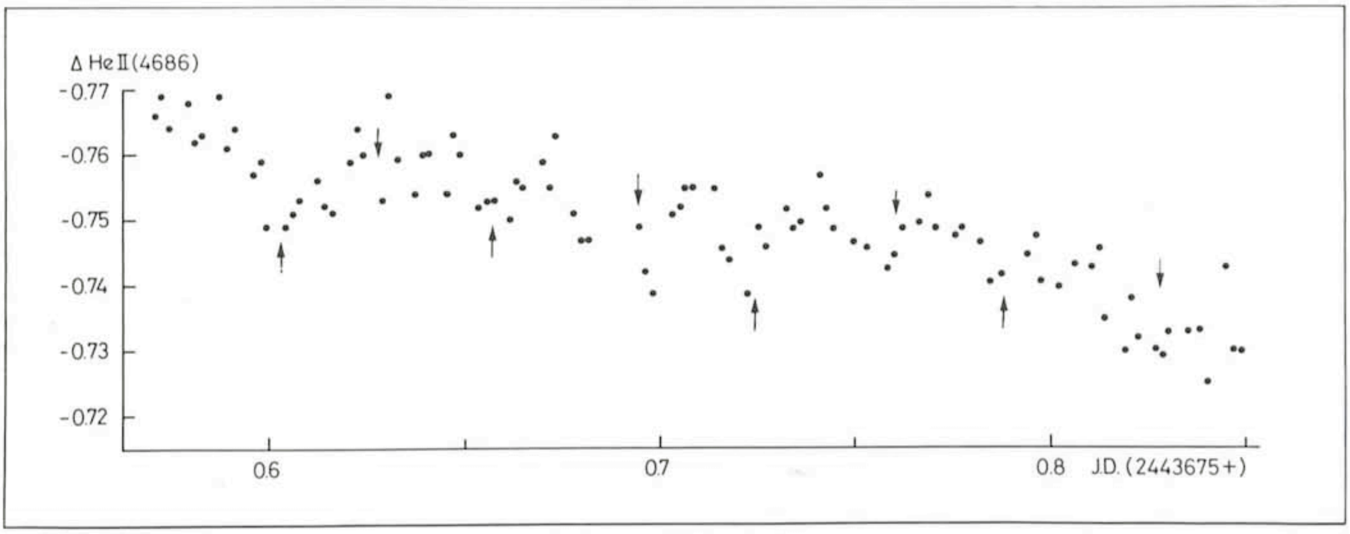


Fig. 2: *The λ 4686 He II light-curve of 4U 1700-37. The arrows ↓ separate time intervals equal to the pulsation period whereas the arrows ↑ denote secondary minima.*

A Supernova in the South

Every year, several supernovae are discovered in the northern celestial hemisphere, mainly by astronomers at the Palomar and Asiago (Italy) observatories. These supernovae normally reach magnitude 14–15 during the maximum before the slow decline in brightness sets in. They occur in relatively faint galaxies and it is important to discover them, not only because they represent rare events, but also because spectroscopic studies can reveal the composition of the material that is thrown out into interstellar space from the exploding star. The statistics show that in a medium-size galaxy like our own, the Milky Way, there is about one supernova per 10–30 years. See also the article about supernova remnants by M. Dennefeld in the *Messenger* No. 13, p. 20.

A new, very faint supernova was discovered on September 23, 1978 by W. Zealey and S. Lee at the UK Schmidt Telescope Unit at Siding Spring, Australia. They found the object on a plate obtained of a field in the constellation Grus. South-west of the bright star Theta Gruis, near a rich cluster of galaxies, they noted the 20^m star, near an interacting pair of galaxies. They later obtained the spectrum of the supernova with the 3.9 m Anglo-Australian telescope, together

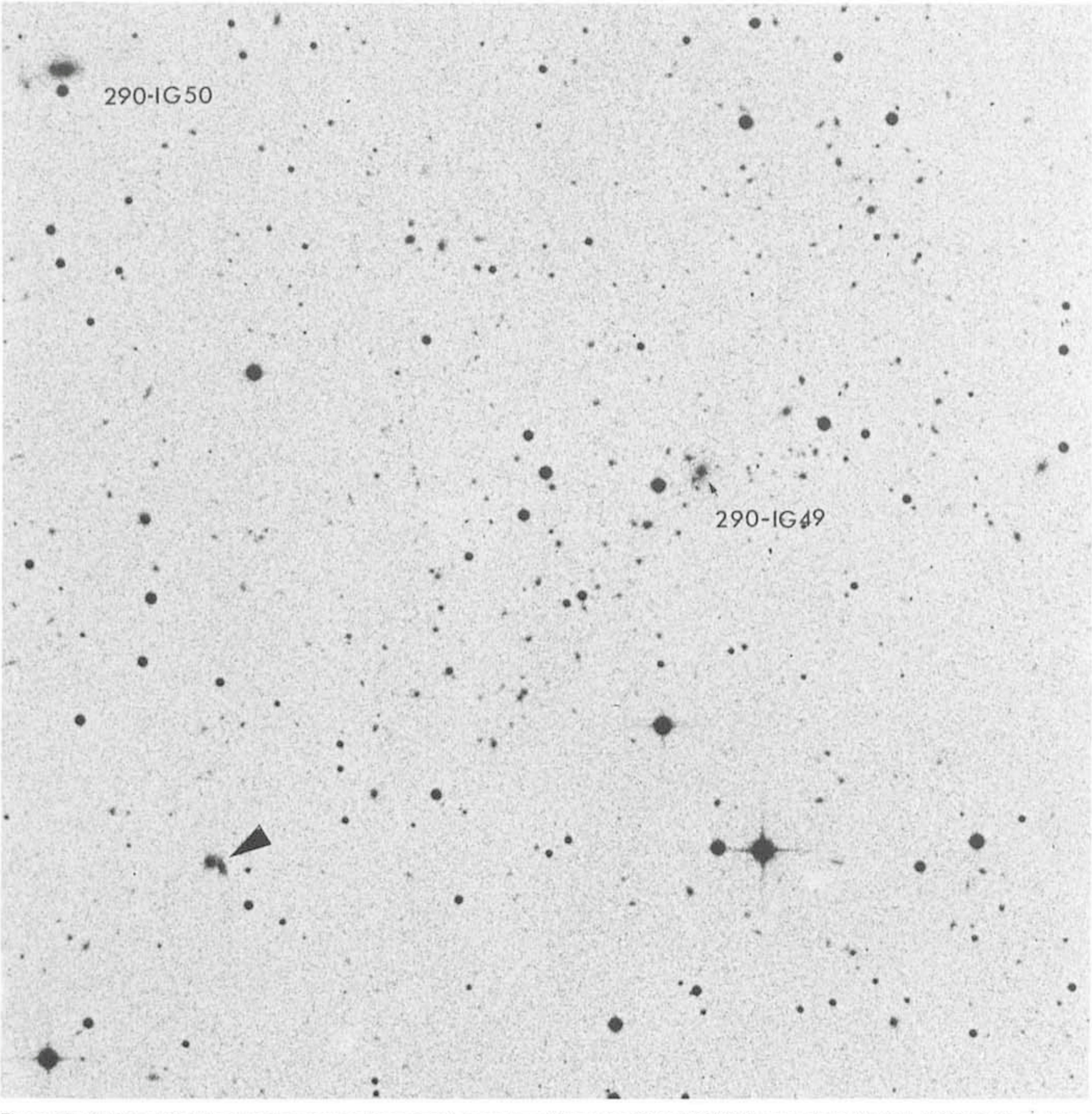


Fig. 1: *The field in which the supernova was discovered, reproduced from the 1974 ESO (B) Survey plate (IIa-O + GG 385, 60 min). Two galaxies which have received designations in the ESO/Uppsala survey of the ESO (B) Atlas are indicated. The supernova occured in the galaxy pair indicated by an arrow. It is not yet known whether they are members of the cluster in which the brightest galaxy is ESO 290-IG 49. The scale is about 1 arcmin mm^{-1}.*

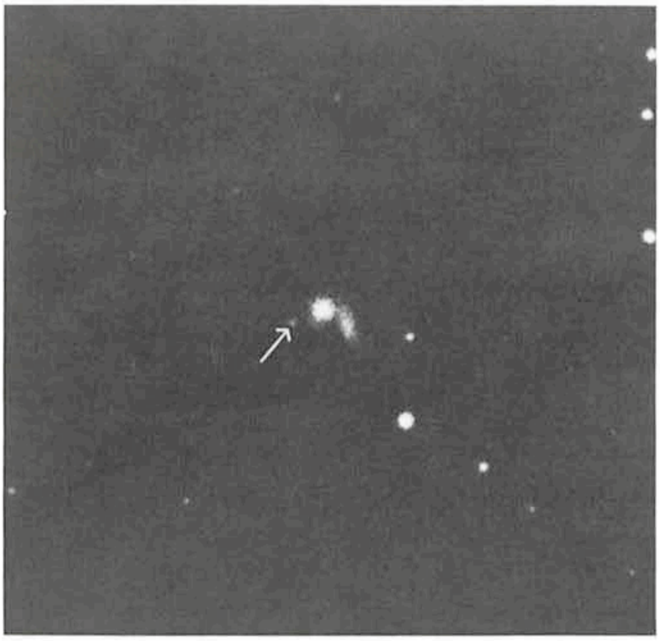


Fig. 2: *A small part of a confirmatory ESO Schmidt plate from September 29, 1978, showing the supernova (arrow).*

with R. F. Carswell and M. G. Smith. The spectral lines indicate a type I supernova, and another spectrum of the parent galaxies gives a radial velocity of approximately 21,000 km s^{-1}, i.e. a distance of 420 Mpc.

A plate was obtained with the ESO Schmidt telescope on La Silla on September 29.1, on IIIa-F + GG385, exposure time 45 min. The broad spectral response (3900–7000 Å) makes it easy to see the supernova, south-east of the interacting galaxy pair.

This supernova is one of the faintest and most distant that has ever been discovered.

List of Preprints Published at ESO Scientific Group

September–November 1978

31. M. CASSE, D. KUNTH, J. M. SCALO: A Constraint on the Influence of Density Waves on the Rate of Star Formation. Submitted to *Astronomy and Astrophysics.*
32. J. MATERNE: The Structure of Nearby Groups of Galaxies: Quantitative Membership Probabilities. Submitted to *Astronomy and Astrophysics.*
33. R. HAEFNER, R. SCHOEMBS, N. VOGT: The Outbursts of the Dwarf Nova VW Hydri: A comparative Study of short and long Eruptions. Submitted to *Astronomy and Astrophysics.*
34. M. SALVATI: Relativistic Corrections in the Theory of Expanding Synchrotron Sources. Submitted to *Astrophysical Journal.*
35. D. KUNTH, W. L. W. SARGENT: A Spectroscopic Survey of the Blue Compact Zwicky Galaxies. Submitted to *Astronomy and Astrophysics.*
36. M. P. VERON, P. VERON: A Study of the 4 C Catalogue of Radio Sources between declinations 20° and 40°. I. 318 MHz Flux Density Measurements. Submitted to *Astronomy and Astrophysics,* Suppl. Series.
37. P. VERON: The Luminosity Function of Seyfert 1 Galaxy Nuclei and BL Lac Objects and the X-ray Background. Submitted to *Astronomy and Astrophysics.*

Construction of ESO Headquarters Building Started

The construction work of the ESO Headquarters building in Garching started in early October this year.

By the middle of November the excavation works were well in progress and some of the foundations were already laid (see photograph).

It is expected that the established time table (with termination in early 1980) can be adhered to.

HD 93250—Weight Champion Among the Stars?

R. P. Kudritzki

The earliest O-stars have masses around 100 M⊙. Dr. Rolf-Peter Kudritzki from the Institute for Theoretical Physics in Kiel, FRG, now believes that one of the stars he recently observed on La Silla may be even heavier.

The O3-stars in the η Car complex belong to the most luminous and most massive stars in our galaxy. According to Conti and Burnichon (1975, *Astron. Astrophys.* **38,** 467), these stars form the very hot end of the main sequence. However, the integral parameters of these objects, like mass, luminosity, effective temperature, etc. are rather uncertain. This is mainly due to the absence in their spectra of neutral helium lines, which are the usual temperature indicators for O-type stars.

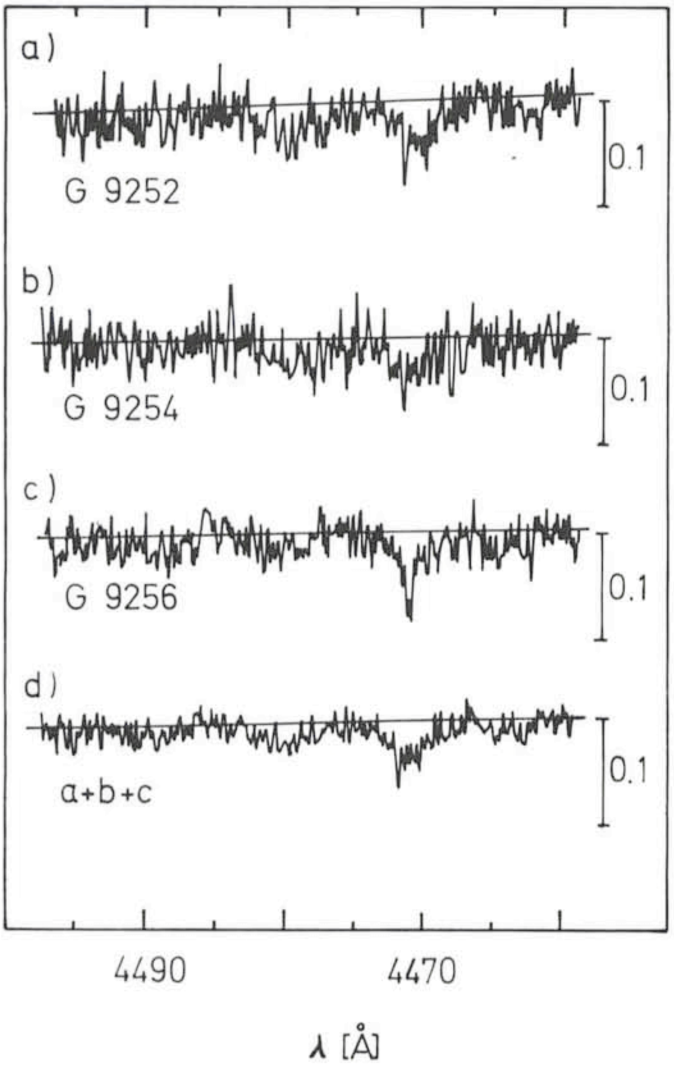


Fig. 1: *Intensity tracings of three 12 Å/mm plates (emulsion Kodak IIIa-J) of HD 93250 at 4470 Å. Tracing (d) is the superposition of the single plates (a), (b), (c). All tracings show the weak and shallow He I λ 4471 line.*

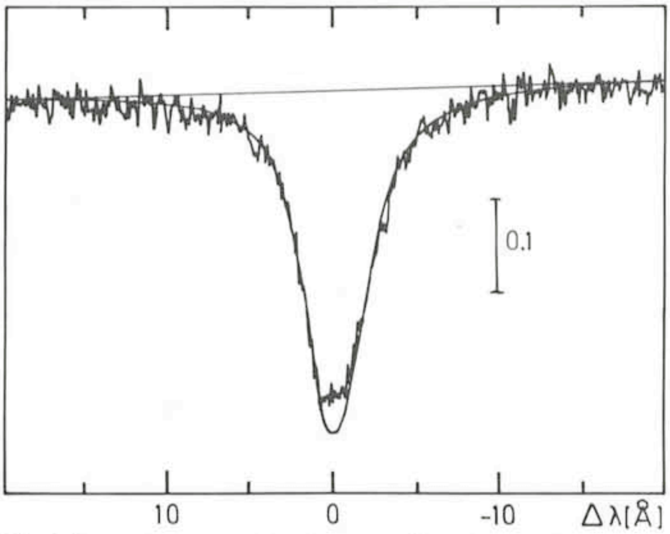


Fig. 2: *Intensity tracing of Hγ (superposition of three plates). The smooth curve is the computed profile of the final non-LTE model. In the line core the observed profile is filled up by the emission of the Carina nebula around HD 93250.*

To overcome this difficulty, we started a new observing programme in March 1978, using the coudé spectrograph at the ESO 1.52 m telescope. Contrary to earlier observers, we used Kodak IIIa-J plates instead of the more common IIa-O

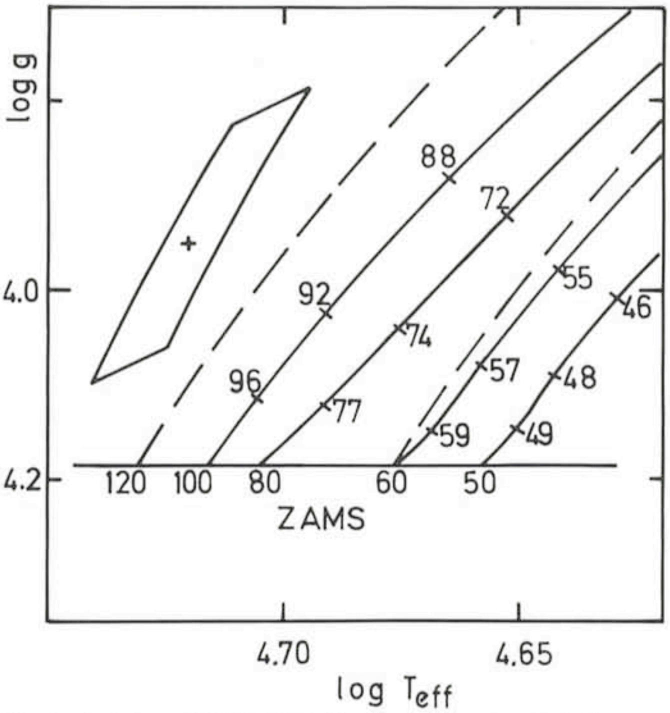


Fig. 3: *Position of HD 93250 (+) in the (log g – log T_{eff})-diagram and corresponding error box. In addition, the zero age main sequence (ZAMS) and evolutionary tracks are shown. The full drawn lines are tracks including mass-loss (de Loore et al., 1978,* Astron. Astrophys. **67,** *373), and the dashed lines represent tracks without mass-loss. Numbers refer to masses in solar units.*

plates. And indeed, the application of this low-noise, high-contrast spectroscopic emulsion allowed, for the first time, the identification of a very weak He I λ4471 line in the spectrum of an O3-star. This is demonstrated by figure 1, which shows three spectrograms (12 Å/mm dispersion) of the O3-star HD 93250 at this wavelength. The fourth tracing is the superposition of the three spectrograms.

According to our theoretical non-LTE calculation, the red neutral helium line λ5876 should be at least twice as strong as λ4471. We therefore took some red spectrograms of HD 93250, which, as expected, allowed us to identify λ5876.

The detection of these neutral helium lines makes it possible to determine more precisely the effective temperature and the gravity and, from these, the radius, luminosity and mass. To do so, we carried out detailed non-LTE calculations. The fit of the line spectrum of neutral and ionized helium as well as of hydrogen (fitting the profiles, not only the equivalent widths, see figure 2) yields $T_{\rm eff} = 52500$ K, log g = 3.95 (cgs) and normal helium abundance. The position in the (log g, log $T_{\rm eff}$)-diagram, when compared with evolutionary tracks (also including mass-loss), indicates that HD 93250 is a very massive object with more than 120 $M_\odot$ (see fig. 3). This is supported by the distance of HD 93250 (3000 ± 400 pc), which is obtained from its membership in the very young open cluster Tr 16 (Feinstein et al., 1973, *Astron. Astrophys. Suppl.* **12,** 331). By comparison with the flux of our final non-LTE model, we then obtain $R \approx 19\,R_\odot$, $\log L/L_\odot \approx 6.4$ (see fig. 4). If we compute the mass from the gravity and the radius, we obtain $M/M_\odot \approx 120$.

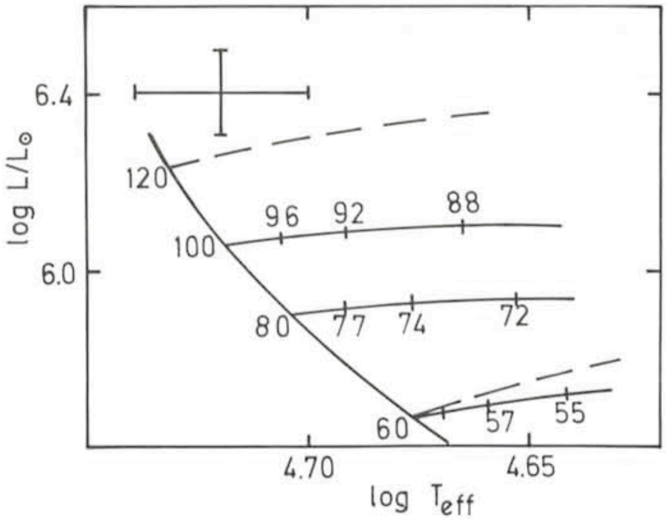


Fig. 4: *Position of HD 93250 in the HRD. The evolutionary tracks are the same as in figure 3.*

So, even when taking into account realistic errors for all of these quantities, it appears unavoidable to conclude that HD 93250 is in fact a main-sequence star, more than *one hundred* times heavier than the Sun!

The International Ultraviolet Explorer (IUE)

A. Heck, F. Beeckmans, P. Benvenuti, A. Cassatella, J. Clavel, F. Macchetto, M.V. Penston, P.L. Selvelli, and D. Stickland.

European and American astronomers received a beautiful new telescope when the International Ultraviolet Explorer was launched earlier this year in a collaboration between NASA, ESA and SRC. IUE is the first space telescope to be operated like a telescope on the ground, by "visiting" astronomers together with observatory staff members. Dr. André Heck, together with the VILSPA Observatory staff based at the ESA Villafranca Satellite Tracking Station, ESTEC and the UK IUE Project, informs us about the satellite and the fantastic observations that have been made with it. During one session, simultaneous observations were made with the IUE and with three ESO telescopes at La Silla.

The Satellite

The IUE satellite, launched successfully on January 26, 1978, is a joint undertaking on the part of NASA, the United Kingdom Science Research Council (SRC) and the European Space Agency (ESA). It has been developed as a general facility for observing the ultraviolet spectra of astronomical sources over the wavelength range from about 1150 Å to 3200 Å. NASA provided the spacecraft plus the optical and mechanical portions of the scientific instrument, while the SRC provided the television cameras used to record the spectroscopic data. ESA's contribution has been the deployable solar-cell array and the operation of the European ground station at Villafranca del Castillo, near Madrid in Spain. A second ground station is located at NASA's Goddard Space Flight Center, Greenbelt, U.S.A.

The scientific aims of the project, unchanged since the earliest studies of its feasibility, are:

- to obtain high-resolution spectra ($R \sim 10^4$) of stars of all spectral types in order to determine their physical characteristics more precisely;
- to study gas streams in and around some binary systems;
- to observe faint stars, galaxies and quasars at low resolution ($R \sim 250$) and to interpret these spectra by reference to high-resolution spectra;
- to observe the spectra of planets and comets as these objects become accessible;
- to make repeated observations of objects known or newly found to show variable spectra;
- to define the modifications of starlight caused by interstellar dust and gas more precisely.

The scientific aims of IUE are achieved by both high-resolution spectra (~0.2 Å) of bright objects and low-resolution spectra (~8 Å) of fainter objects. Determining the equivalent widths of faint lines used to measure chemical abundance, or the profiles of stronger lines used to study gas motions, requires a spectral resolution of at least 0.2 Å.

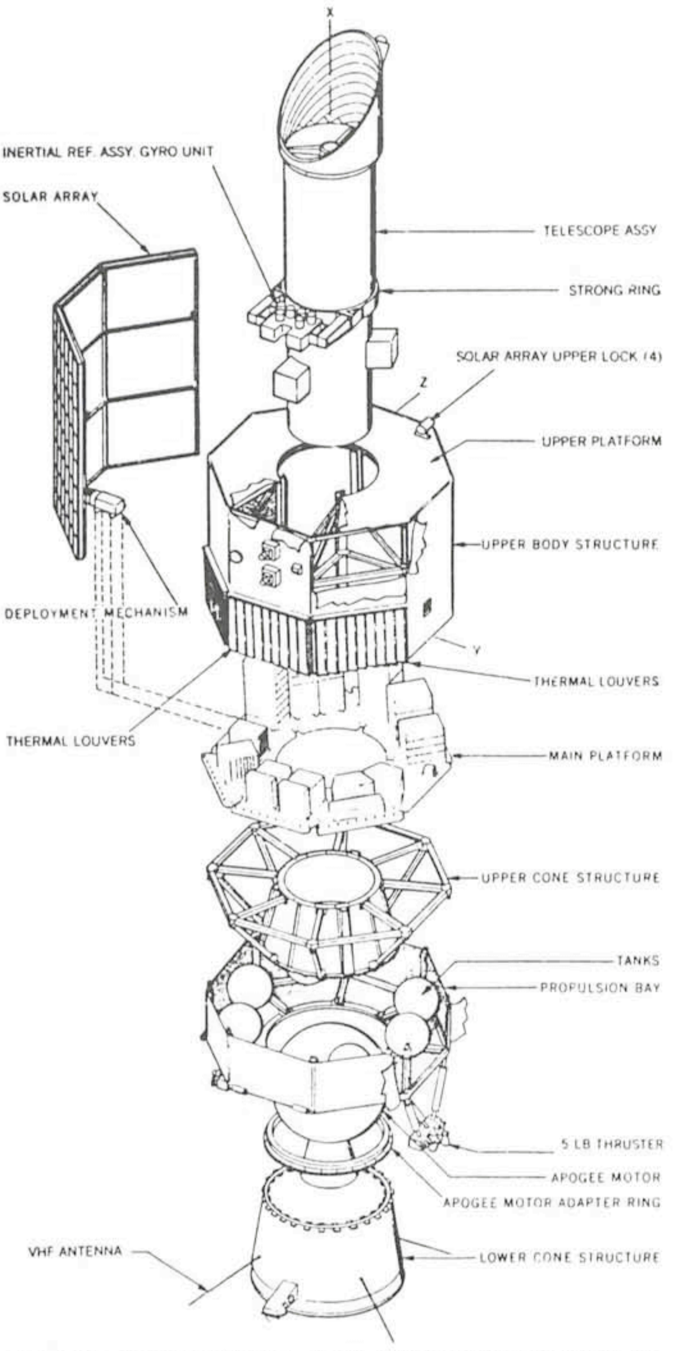


Fig. 1: *An "exploded" view of the International Ultraviolet Explorer Satellite.*

Low-dispersion spectroscopy, on the other hand, serves primarily in the observation of faint sources. The observing programmes calling for this capability either do not require high resolution for analysis or they involve sources with intrinsically broad spectral features. The emphasis is placed on limiting magnitude rather than resolving power. The desire to record complete ultraviolet spectra rather than selected spectral regions dictates the use of spectrographs able to record a spectral image, rather than spectrum scanners.

The IUE scientific instrument consists of a telescope, an offset star tracker used for fine guidance, echelle spectrographs and television cameras. The optical characteristics of the Ritchey-Chretien-type telescope are given by the following table:

IUE Telescope Parameters

Figure	Ritchey-Chretien
Clear aperture	45 cm
Central obscuration (baffled)	22 cm
Primary focal length	125 cm
Effective focal length	675 cm
Focal ratio	50 cm
Mirror separation	102.7 cm
Back focal distance	17.5 cm
Plate scale	30.6 arc sec/mm
Image quality	3 arc sec
Field of view	16 arc min

The acquisition field of view of 16 arcmin is mapped by the fine error sensor in order to identify the target and an eventual guide star, which can be as faint as the 14th magnitude. The fine error sensor, in combination with the gyro package, maintains ~1 arcsec guidance for as long as is required.

The two spectrographs (optical data in the following table) can be operated in a low-dispersion mode (low-dispersion grating only) or in a high-dispersion mode by addition of a high-dispersion echelle grating in place of a plane mirror. They are physically separated and correspond to the following wavelength ranges:

Short wavelength spectrograph 1150 to 2000 Å
Long wavelength spectrograph 1800 to 3200 Å

IUE Spectrograph Optics

Optical Element	Short-Wavelength Spectrograph	Long-Wavelength Spectrograph
Offset mirrors	none	two 45° flats
Collimator radius	189 cm	189 cm
Low-dispersion mirror	flat	flat
Echelle grating		
frequency	101.9 mm^{-1}	63.2 mm^{-1}
blaze angle	45.5 degrees	48.1 degrees
off-normal angle	10.2 degrees	10.2 degrees
Spherical grating		
frequency	313.0 mm^{-1}	200.0 mm^{-1}
radius	137 cm	137 cm
Camera select mirror	45° flat	45° flat
High-dispersion resolving power	10^4	10^4
Low-dispersion resolution	8 A°	8 Å

The detectors are SEC Vidicon cameras. Each spectrograph has two apertures: a 3 arc sec circle and a 10 x 20 arc sec rectangle.

The Orbit

By being in a synchronous orbit such that it can be in continuous contact with the two operations centres, at Goddard Space Flight Center and Villafranca, IUE differs conceptually from previous orbiting observatories, which communicated with ground stations only intermittently and so had to be self-contained, automated systems that acquired data while not under direct ground control. In the case of IUE, control and performance monitoring is exercised continually from the ground. The telescope field is displayed to the observer, who can identify his target star and direct the course of the observation essentially in real time. The "observatory", therefore, consists of the ground control centre where the astronomer views the television monitors, and the optical and electronic instrumentation in orbit at synchronous altitude.

Two significant scientific advantages of the synchronous orbit are that the astronomer has physical access to the observatory, whereby he can participate directly in the telescope control loop, and the observing circumstances develop at the diurnal rate so that plans and real-time decisions can be made in an effective and orderly manner. Also, the earth subtends an angle of 17° as seen by the telescope, and the area of sky available at any given time is much greater than from lower orbits or from the ground. Moreover, the region of the celestial sphere periodically occulted by the earth is also greatly reduced. As a result, in most parts of the sky, long exposures or the monitoring of variable phenomena need not be periodically interrupted because of earth occultations.

Pointing within 43° of the sun is prohibited. Pointing within 15° of the anti-sun requires special planning to avoid telescope defocus problems. Pointing within 25° of the earth may be restricted during image readout because of antenna null problems, but observations in this region are permissible.

In exchange for its contribution to the project, Europe has been allotted eight hours of satellite observing time per day, shared equally between ESA and SRC.

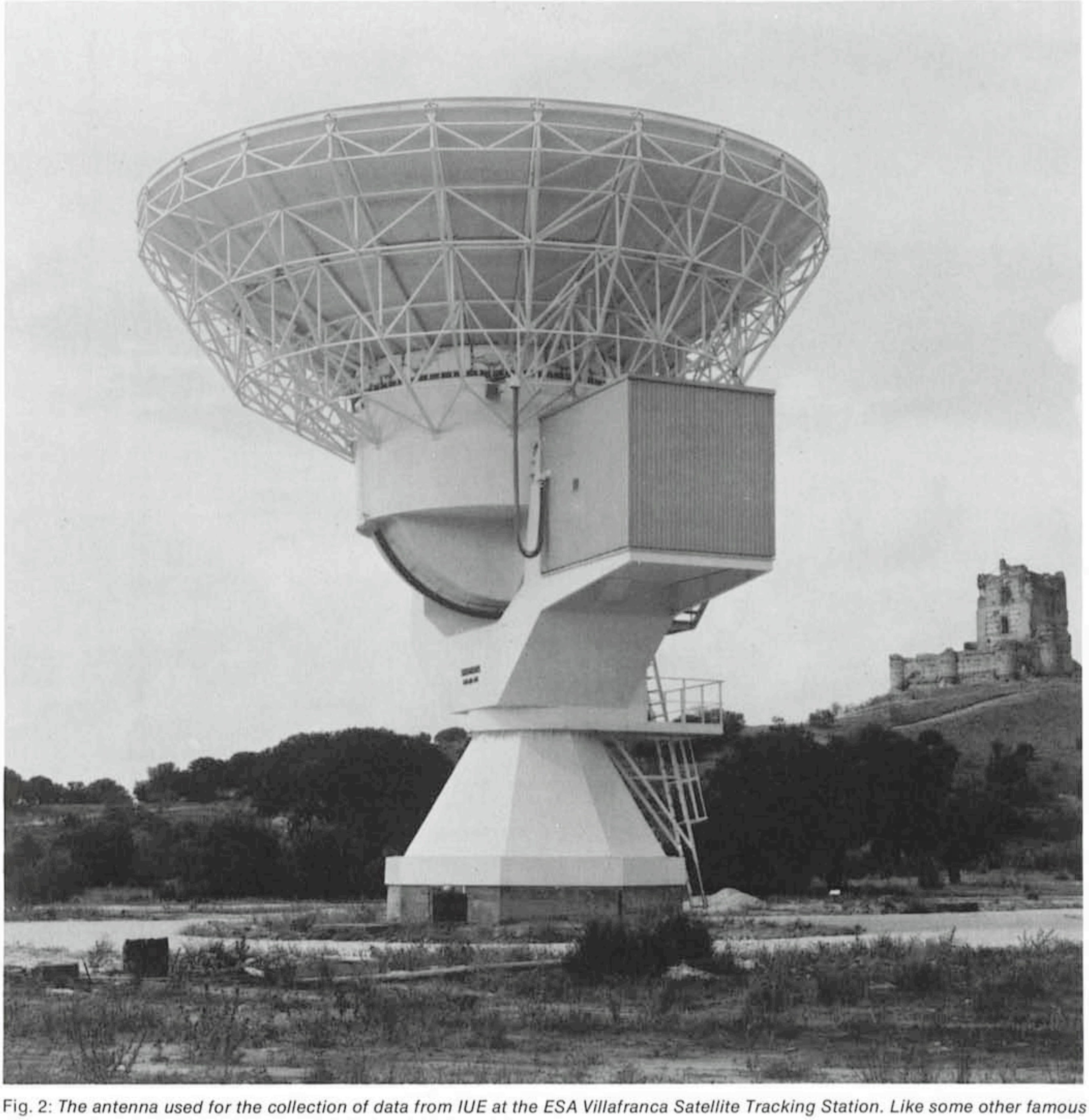


Fig. 2: *The antenna used for the collection of data from IUE at the ESA Villafranca Satellite Tracking Station. Like some other famous observatories, the facilities lie close to a distinguished castle!*

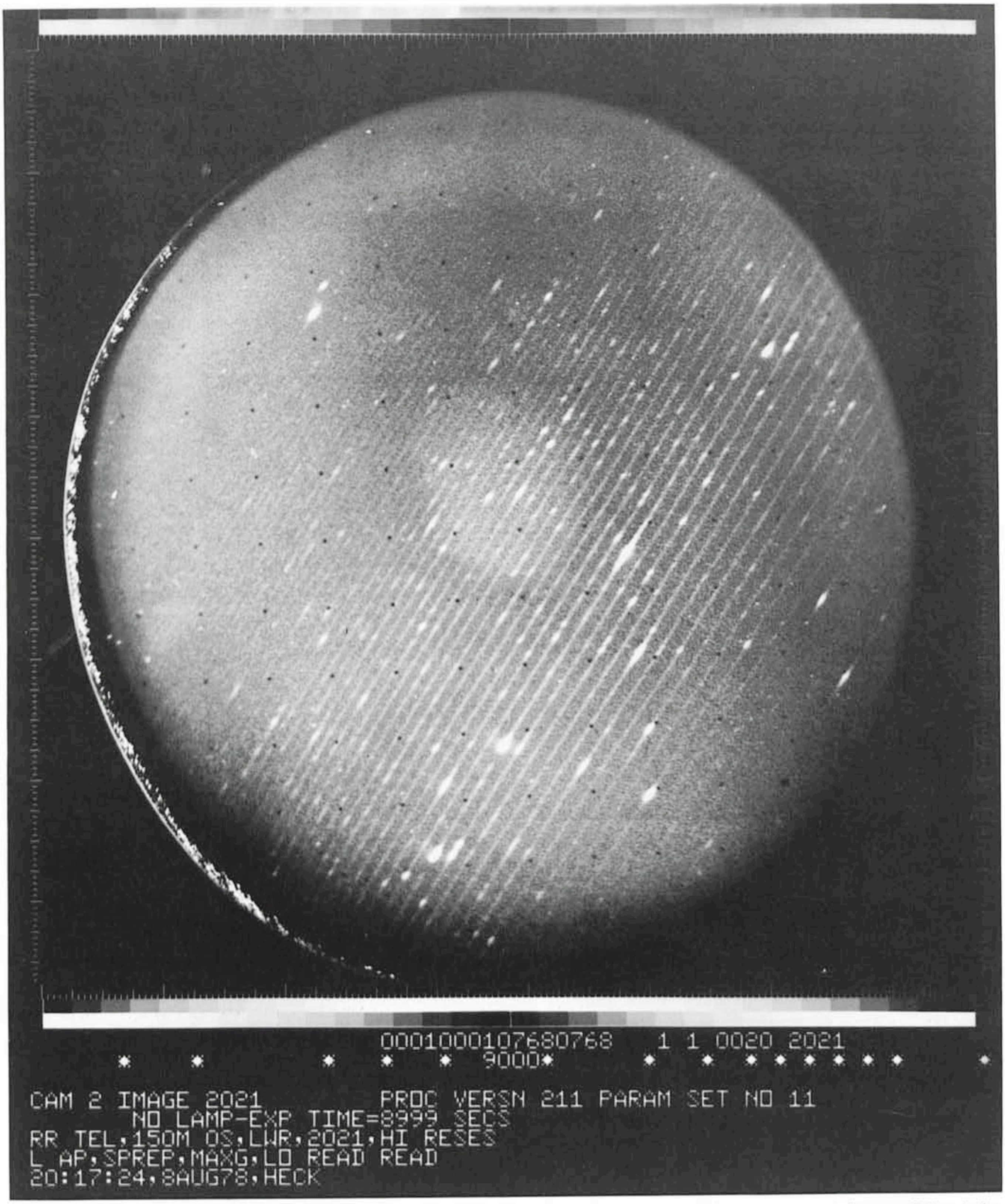


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Fig. 3: *The "long-wavelength", high-dispersion UV echelle spectrum of the slow nova RR Tel. This spectrum contains over 300 emission lines!*

Observing with the IUE

To ensure that the observers visiting the ground stations are able to make maximum use of the satellite observing time available to them, a small group of resident astronomers are available to provide assistance and to guide and train visiting scientists, many of whom are astronomers from universities, conventional observatories and other institutes.

During his shift, the observer directs the activities of the spacecraft and scientific-instrument operators and a data-reduction specialist. An observing sequence starts with the observer requesting that the telescope be slewed to the coordinates of his first target. After the slews have been accomplished, a fine-error-sensor image is commanded, resulting in a display on the television monitor of the positions of all stars brighter than a predetermined magnitude. The observer can then compare this display with a finder chart, identify his target star and designate a suitable guide star.

When the target image is in the correct aperture, the spectrograph camera high voltage is commanded *on* to start the exposure. During exposure, the guidance quality is monitored on the ground by examining the signal from the fine-error sensor. At the end of the exposure, the tube high voltage is turned off, and the camera commanded to read out the image.

The telescope may be held on target until the observer has had an opportunity to examine the data. About 20 minutes after the end of the exposure, the raw spectrum from the television camera can be displayed on an television monitor to see if the observation should be repeated or if the subsequent observing schedule should be modified in some way. When the observer determines that useful data have been obtained, the spectral image is stored for full processing and the observing session continues.

Routine data processing, defined as those calculations that require special knowledge of IUE but that do not require astronomical interpretation of the data, is done by the observatory staff. These tasks include noise and distortion removal, wavelength determination to an accuracy comparable with the spectral resolution and photometric calibration.

The standard outputs of the data processing are magnetic tapes, plots and photographic representation of the images.

In about six months of observation at the date of writing, numerous important results have been obtained with IUE in various fields of astronomy.

To the end of September 1978, 57 groups of guest observers from 11 different countries have come to VILSPA and taken 878 spectral images on IUE (some containing more than one spectrum). An average of 7 images per day was obtained in September—a marked improvement over the first scientific target in Commissioning which took 24 hours to observe! These image numbers closely approximate the 33 per cent expected from Europe's one-third time on the satellite. IUE has shown its versatility by obtaining from Villafranca ultraviolet spectra of planets, the interplanetary medium, stars of all spectral types from O to M as well as Wolf-Rayet, symbiotic, nova-like, X-ray emitting and T Tauri stars, planetary nebulae, supernova remnants, galaxies—including in particular Seyfert and radio galaxies—BL Lac objects and quasars. IUE has proven capable, in long exposures, of detecting and obtaining useful spectroscopic information on an 11th magnitude Seyfert nucleus in high dispersion and a quasar of almost 18th magnitude in low dispersion.

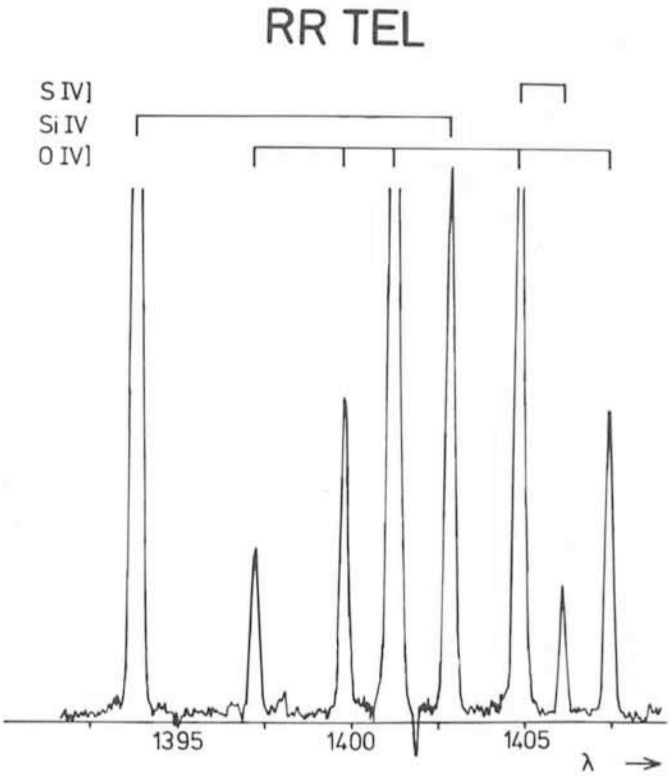

Fig. 4: *A tracing of a portion of the "short-wavelength" UV spectrum of the slow nova RR Tel, showing the group of strong lines from O IV], Si IV and S IV] near 1400 Å.*

Joint IUE-ESO Observations of RR Tel

In particular, interesting joint observations from space and ground were performed on June 20, 1978 by astronomers observing from the ESO site at La Silla and from the European Space Agency Villafranca Satellite Tracking Station (Vilspa) in Spain.

At the latter station, the real-time operation shift on the International Ultraviolet Explorer (IUE) satellite was available for the resident astronomer's programme. As André Heck was observing at that time with the 50 cm at La Silla (photometry in Strömgren and Crawford systems), it was decided to perform simultaneous spectrophotometric observations of the slow nova RR Telescopii. Thanks to the collaboration of J. Surdej and N. Cramer respectively, the star was also observed at the coudé focus of the 1.5 m ESO telescope (two spectra at 20 Å/mm—one in the blue region, one in the red region) and at the 40 cm Swiss telescope (photometry in Geneva system). The observer at Vilspa was P. L. Selvelli. Further UV observations were performed later at Vilspa by other resident staff.

The spectra, covering both UV and visible ranges, are quite exciting and contain about four hundred emission lines. They are presently being reduced, as are the photometric observations which are primarily useful for monitoring possible variations. All the Vilspa Observatory staff are participating in the reduction and the discussion of the data.

RR Tel was extensively observed and studied by the late A. D. Thackeray and it is hoped that the combination of visible and UV data will improve our understanding of the complex nature of this object. At the time of writing, we have confirmed its binary nature as the optical data show a late-type star whereas the continuum energy distribution is consistent with a B-type star. Emission lines identified so far include species up to about the fourth stage of ionization. The presence of some lines from highly excited levels may indicate the presence of hot gas of up to 260,000 K.

This example of joint observations from ground and space is a forerunner of what will most probably be very common in the future.

ESO, the European Southern Observatory, was created in 1962 to . . . establish and operate an astronomical observatory in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organizing collaboration in astronomy . . . It is supported by six countries: Belgium, Denmark, France, the Federal Republic of Germany, the Netherlands and Sweden. It now operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where nine 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 will be located in Garching, near Munich, where in 1980 all European activities will be centralized. The Office of the Director-General (mainly the ESO Administration) is already in Garching, whereas the Scientific-Technical Group is still in Geneva, at CERN (European Organization for Nuclear Research), which since 1970 has been the host Organization of ESO's 3.6-m Telescope Project Division.

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

The ESO MESSENGER is published in English four times a year: in March, June, September and December. It is distributed free to ESO employees and others interested in astronomy.

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Editor: Richard M. West
Technical editor: Kurt Kjär

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Schleißheimer Straße 17
D-8046 Garching b. München
Fed. Rep. of Germany
Tel. (089) 3204041-45
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Printed by Universitätsdruckerei
Dr. C. Wolf & Sohn
Heidemannstraße 166
8000 München 45
Fed. Rep. of Germany

ALGUNOS RESUMENES

El cuento del Planeta Menor (2100) RA-SHALOM

Durante los últimos años ha aumentado considerablemente el número de conocidos planetas menores del tipo Apolo. Dos astrónomos se destacan como descubridores de objetos particularmente interesantes: Eleanor F. Helin y Charles T. Kowal del California Institute of Technology en Pasadena.

Hace tres años la Sra. Helin descubrió el primer planeta menor con una órbita *menor* a la de la tierra. El planeta, 1976 AA, fue nombrado por un dios del sol egipto, ATEN. Poco más tarde fue descubierto otro planeta que tendría una órbita similar, quedando mayormente dentro de la órbita de la tierra (1976 UA). Y ahora, en septiembre de 1978, la Sra. Helin ha encontrado un tercero, 1978 RA. Se ha propuesto de darles el nombre de «Aten» a estos tres objetos, a fin de diferenciarlos de otros asteroides Apolo, los cuales, a pesar de cruzar la órbita de la tierra, aun tienen períodos orbitales mayores a un año.

1978 RA fue descubierto el 10 de septiembre de 1978 con el telescopio Schmidt de 46 cm de Palomar. Se hicieron más observaciones durante las noches consecutivas, y muy pronto se verificó que tenía una órbita poco usual.

Dr. J.G. Williams del Jet Propulsion Laboratory, igualmente en Pasadena, tuvo la excelente idea de buscar en la literatura sobre posibles observaciones anteriores del 1978 RA, y pudo demostrar que 1978 RA era idéntico con el planeta menor 1975 TB, que fuera encontrado por R. M. West en dos placas Schmidt de ESO a fines de 1975. Sin embargo, en ese entonces sólo existían dos placas, y la órbita no pudo ser determinada sin ambigüedad.

Conectando las posiciones de 1975 y 1978 fue posible establecer la órbita de 1975 TB = 1978 RA con gran precisión. Y resultó que tenía el menor período conocido entre todos los asteroides, de tan sólo 277 días, o casi un $^3/_4$ año.

De acuerdo a la prerrogativa de los descubridores, la Sra. Helin decidió dar el nombre de RA-SHALOM al nuevo planeta (no valían las observaciones de ESO, ya que no fue posible establecer la órbita en base de tan sólo dos observaciones).

El número 2100 fue adjudicado a RA-SHALOM en el MPC 4541 (Minor Planets and Comets Circular) y en el MPC 4548 su nombre fue explicado en la forma siguiente: »Nombrado por su descubridor por el dios egipto del sol RA, quien simboliza la luz y la vida, y por SHALOM, el tradicional saludo hebreo que significa paz. Este nombre fue elegido para conmemorar la Conferencia de Paz del Medio Oriente en Camp David, en cuyo período fue descubierto este singular objeto. Que sirva como símbolo del deseo universal de paz.»

RA-SHALOM es el único planeta del tipo Apolo (o Aten) que fue descubierto dos veces. Es interesante notar que la órbita fue calculada por el Dr. Brian Marsden en 1975 en base de las observaciones de ESO, quien entre otras posibles órbitas determinó igualmente la órbita correcta. Sin embargo, en ese entonces no se conocía ningún planeta menor que tuviera un período menor a un año y ese resultado no fue aceptado.

Cometas y más cometas

Entre el 1° de septiembre y el 11 de octubre de 1978 hubo una cadena de descubrimientos de cometas raramente vista.

Comenzó el 1° de septiembre cuando el astrónomo amateur da Silva Campos en Sudáfrica y T. Haneda en Japón descubrieron independientemente el mismo cometa llamado ahora Haneda-Campos (1978 j). El cometa se mueve en una órbita elíptica con un período de tan sólo 6 años, posiblemente por haberse acercado a Júpiter en 1957 y en 1969 y fuera «capturado». Buscando en los archivos de placas en Pasadena y en Ginebra se encontraron dos imágenes de predescubrimiento del 1978 j, de comienzos de agosto, la primera del telescopio Schmidt de 46 cm de Palomar y la segunda del telescopio Schmidt de ESO (vergüenza para los profesionales!).

El cometa Giclas (1978 k) descubierto en el Lowell Observatory en Arizona, USA, el día 8 de septiembre, fue seguido por el cometa Machholz (1978 l) descubierto el día 13 por un amateur de California, Don E. Machholz.

Siguieron entonces el cometa Seargent (1978 m) (D.A.J. Seargent, Australia), el cometa Fujikawa (1978 n) (S. Fujikawa, Japón), y el cometa Bradfield (1978 o) (W.A. Bradfield, Australia) descubiertos en los días 2, 10 y 11 de octubre respectivamente. Los tres fueron captados cuando se encontraban cerca de su perihelio y están actualmente palideciendo.

El Explorador Ultravioleta Internacional (IUE)

Astrónomos europeos y americanos recibieron un lindísimo nuevo telescopio al lanzarse el IUE («International Ultraviolet Explorer») a comienzos de este año. El IUE es una colaboración entre NASA, la Agencia Europea Espacial (ESA) y el Consejo de Investigación Científica del Reino Unido (SRC). Es el primer telescopio espacial que es operado por astrónomos «visitantes» y observadores de planta en la misma forma que un telescopio con base en la tierra, y ha sido desarrollado para observar los espectros ultravioletas de fuentes astronómicas.

La estación terrestre europea se encuentra ubicada en Villafranca del Castillo, cerca de Madrid, España. Una segunda base terrestre se encuentra en el Centro Aéreo Espacial Goddard de NASA, en Greenbelt, USA.

El IUE se controla continuamente desde la tierra. El campo del telescopio se encuentra desplegado ante el observador quien puede identificar la estrella que desea observar.

El día 20 de junio de 1978 se efectuaron interesantes observaciones conjuntas desde el espacio y la tierra por astrónomos ubicados en ESO, La Silla, y en Villafranca. Como el Dr. André Heck hacía entonces observaciones fotométricas con el telescopio de 50 cm en La Silla, se decidió hacer observaciones espectrofotométricas simultáneamente de la nova lenta RR Telescopii. Gracias a la colaboración de los Drs. J. Surdej y N. Cramer la estrella fue observada también con el telescopio de ESO de 1.5 m y el telescopio suizo de 40 cm. El observador en Villafranca fue el Dr. P. L. Selvelli.

Se están actualmente reduciendo los datos obtenidos y se espera que ellos nos traigan mayores conocimientos sobre la compleja naturaleza de este objeto.