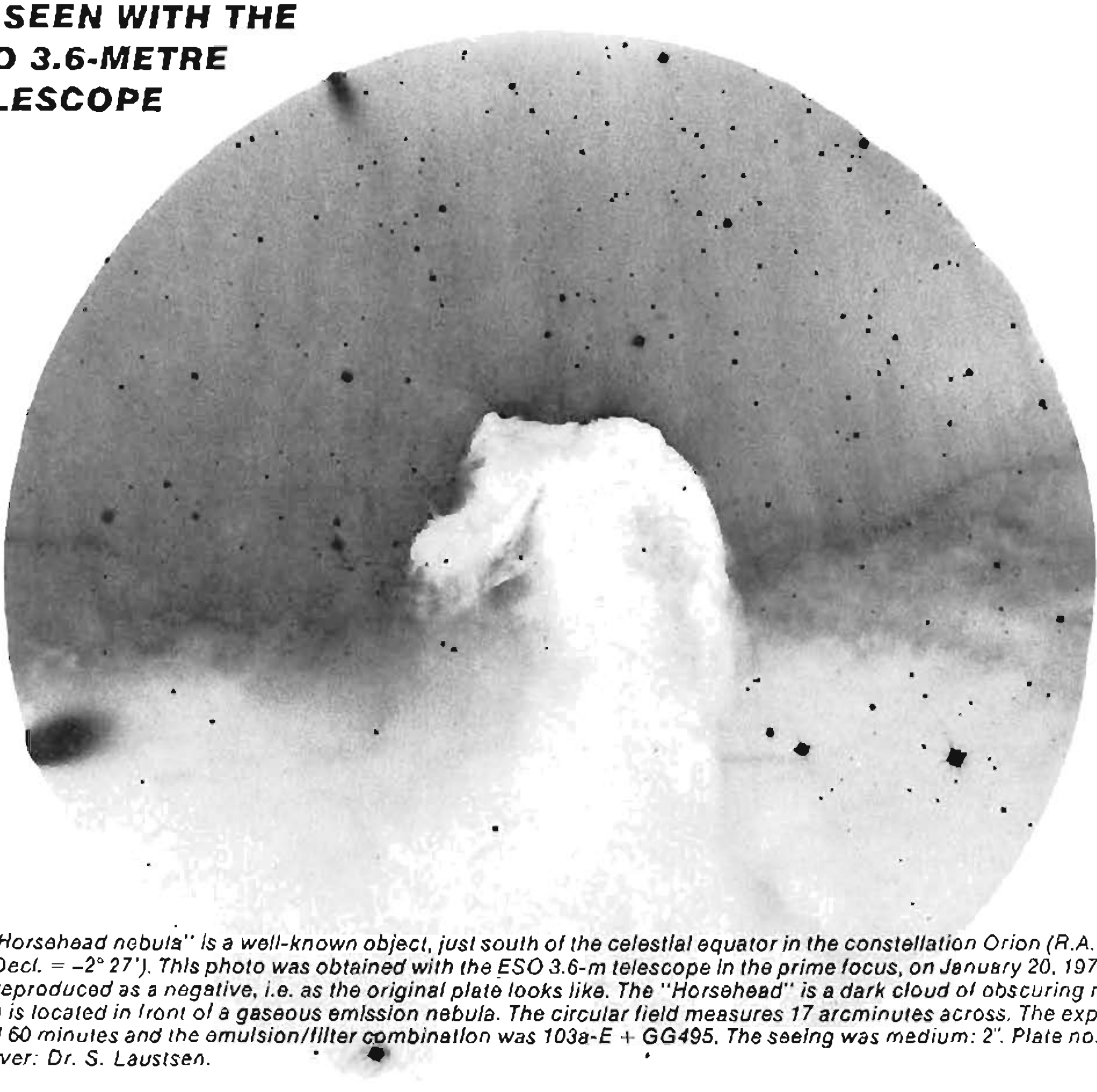
No. 8 — March 1977

THE HORSEHEAD NEBULA AS SEEN WITH THE ESO 3.6-METRE TELESCOPE



The "Horsehead nebula" is a well-known object, just south of the celestial equator in the constellation Orion (R.A. = 05^h 39^m; Decl. = –2° 27'). This photo was obtained with the ESO 3.6-m telescope in the prime focus, on January 20, 1977. It is here reproduced as a negative, i.e. as the original plate looks like. The "Horsehead" is a dark cloud of obscuring matter which is located in front of a gaseous emission nebula. The circular field measures 17 arcminutes across. The exposure lasted 60 minutes and the emulsion/filter combination was 103a-E + GG495. The seeing was medium: 2". Plate no.: 239; observer: Dr. S. Laustsen.

PROFILE OF A VISITOR'S PROGRAMME:

M-type Dwarf Stars and the "Missing-Mass" Problem

Dr. P. S. Thé *from the Astronomical Institute of the University of Amsterdam is a frequent visitor on La Silla, where he often uses the ESO 1-m telescope for measurements of very faint, red (cool) stars. His research programme is intimately connected with one of the greatest enigmas of modern astronomy: there appears to be more mass in the space surrounding the solar system than we actually observe. Whether this "missing mass" is present in the form of black holes, low-luminosity stars or interstellar material, or whether the theoretical considerations that predict the existence of the "missing mass" somehow are wrong, no one knows for sure. But to solve the problem, more accurate observations are needed. Dr.* Thé *outlines recent research in this field and informs about his programme:*

In 1965, the Dutch astronomer J. H. Oort noticed that some mass is missing in the solar neighbourhood. He announced that the mass density of all known objects near the Sun, including interstellar material, is less than what one can derive semi-theoretically from the movements of nearby stars. This deficiency in mass density (i.e. "missing mass") is about 0.05 $M_\odot/pc^3$ (solar masses per cubic parsec). As simple as this discovery seems to be, yet up till now this problem has troubled the minds of many astronomers.

Search for the "Missing Mass"

S. Kumar was one of the first to suggest that there is plenty of mass hidden in what he called "black" dwarfs. The number of these tiny degenerated stars (masses between 0.02 to 0.07 $M_\odot$) in space is probably very large, but they are too faint to be found easily. Recently, Peter van de Kamp has shown that all unseen companions of normal stars contribute enough mass to solve the missing-mass problem. The weakness of these statistical conclusions lies in the fact that they are based on a small number of stars.

Work based on large numbers of stars by W. Luyten (1968) shows that there is no high space density of red stars of small mass. In fact the luminosity function (relative number of stars with a given absolute magnitude) of these red stars of low luminosity reach a maximum around $M_B = 15\overset{m}{.}5$, and drops again for fainter luminosities. The question is whether this effect is real, or if the decrease of the luminosity function is simply caused by incompleteness of the data; faint stars are generally much more difficult to discover and observe than bright ones.

With this in mind, Donna Weistrop (1972) made an ambitious study of the luminosity function (based on 13,820 stars) in the direction of the North Galactic Pole. The space density she derived for faint red stars was much higher than that of Luyten. Her findings were soon supported by the results of Murray and Sanduleak. The density of 0.23 stars/pc^3 found by these astronomers was about four times higher than that of Luyten, and was quite enough to explain the missing-mass problem. It therefore appeared as if this problem was completely solved.

North-South Discrepancy

However, towards the South Galactic Pole several astronomers obtained different results. Derek Jones, W. Gliese, and Thé and Staller found space densities which correspond closely to those of Luyten: about 0.06 stars/pc^3. This North-South discrepancy is a very serious problem, and the above-mentioned astronomers are often blamed for using incomplete material to obtain their results. The following questions arise: Is the distribution of stars above and below the galactic plane not symmetric? Is the sun not situated in the galactic plane, but to the south of it?

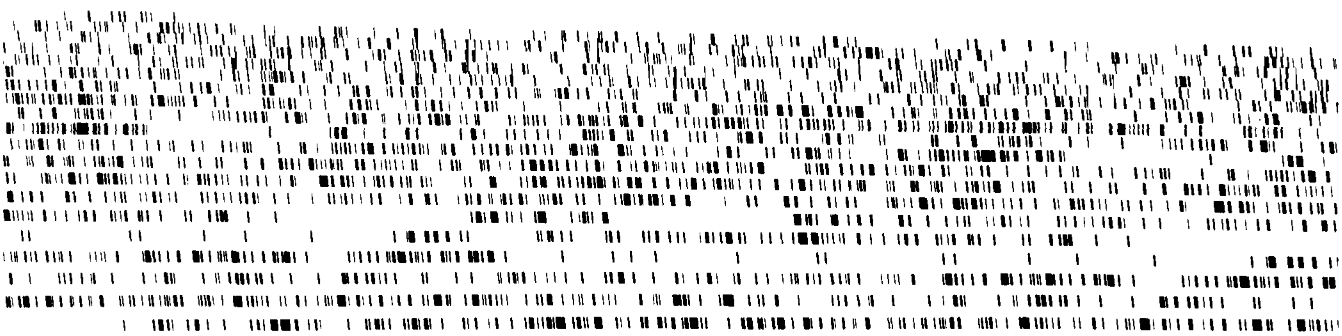
Another serious problem introduced by Murray and Sanduleak is that of the dispersion of the velocities of the M-type dwarfs. They found that their stars not only have small proper motions ($<0\overset{''}{.}2$/year), but also that the dispersion of the velocities of these stars is about half of that of normal M dwarfs. The latter are known to be old population II objects. The assumption that the low-velocity M dwarfs are also old objects contradicts with Spitzer-Schwarzschild's mechanism for the creation of velocity dispersions. Have we then to assume that they are young? Staller explains this problem by the assumption that the low-velocity stars are stars of very low mass, in accordance with the suggestion of Kumar. A rough calculation then shows that these low-mass stars are indeed young objects. If Staller's assumption is correct, then the velocity-dispersion problem is solved.

Theoretically there are more problems in connection with the low-velocity M dwarfs. But this will not be discussed, because recently more observations show that the results by Weistrop as well as by Murray and Sanduleak are erroneous. It turns out that these results are very much influenced by systematic errors in the determination of the colour indices of the red M dwarfs, in such a way that the distances of these stars are estimated too small and that therefore the obtained densities are too high. If these systematic errors are removed, the space densities drop to values similar to those of Luyten

With these important corrections it is now clear that the supposed high space density of M dwarfs is spurious. However, that means that we now are back to the old problem of the "missing mass".

Observations at ESO

Using the ESO facilities at La Silla, we have for many years pursued our study at the Amsterdam Astronomical Institute of very faint red stars (down to magnitude 20 in V) in the direction of the South Galactic Pole. By studying such faint, red stars we hope to obtain a better knowledge of the fainter end of the luminosity function. This again will result in a better understanding of the past history, the birth-rate, and the evolution of these very interesting red stars. It is evident that for reaching the above-mentioned magnitude limit we need a comparatively large telescope, a sensitive and stable photoelectric photometer and equipment for electronographic photometry. There is no doubt that the new ESO 3.6-m telescope will become an important tool for this kind of astronomical research.



A part of the mask for the CORAVEL instrument, here shown in negative. Each line corresponds to a line in the spectrum of a late-type (cold) star. More than 3,000 lines were drawn by a computer programme operating the ESO S-3000 measuring machine in Geneva in a play-back mode. The mask is enlarged several times in this figure.

The CORAVEL

The measurement of radial velocities, i.e. the velocity in the direction of the line of sight, is of fundamental importance in stellar as well as in galaxy astronomy. Until the 1960s the only possible method was to obtain a spectrum on a photographic plate and then measure the displacement of the spectral lines. These observations were extremely time-consuming for faint objects. With the advent of image-intensifying devices, the observing time was drastically reduced, but so was—unfortunately—the accuracy of the measurement, due to geometric distortions in the image tubes. Now, however, the situation has improved very much indeed, as explains Dr. M. Mayor *of the Geneva Observatory, who, together with several European colleagues, is building a spectrometer to determine stellar* radial velocities *by a* correla*tion method.*

The Marseille and Geneva observatories (A. Baranne, M. Mayor and J. L. Poncet) are working together to build two spectrophotometers for stellar radial velocities. Testing of the first machine has been completed. But before giving the results of these tests it could be useful to review the principles of operation of these "spectrovelocimeters".

In the last ten years, the field of stellar radial velocities has been enriched by a new method whose efficacity and precision for late spectral type stars is exceptional. The development of this method and the proof of its reliability are due to R. Griffin at Cambridge. He has been able to measure the radial velocity of a 14th B-magnitude star to within 1 km/s in only 4 minutes at Palomar!

The Doppler shift measurement is done by means of an optical cross-correlation between the stellar spectrum and a mask located in the focal plane of the spectrograph. This mask is designed to stop photons coming from the stellar continuum and is transparent in the regions of the absorption lines. The spectrum is scanned across the mask and the point of minimum light transmission is located. CORAVEL, which is designed to work at the Cassegrain focus, is a fairly compact apparatus with a collimator focal length of only 60 cm. Nevertheless, its echelle grating which is used between the 43rd and 62nd orders gives a mean dispersion of about 2 Å/mm over the 1500 Å spectral range. The total light transmitted by the mask is measured by a photomultiplier. Rapid scanning at about 4 Hz is used to eliminate atmospheric scintillation effects and the correlation function is built up on-line by integration in the memory of the HP 2100 computer. The zero point of the radial velocities is determined by means of a hollow cathode iron lamp which illuminates the entry slit at the beginning and end of each measurement. The reduction of the Earth's motion is immediately done at the end of the measurement.

The mask used in CORAVEL is derived from the spectrum of Arcturus and consists of about 3,000 holes distributed over the 20 orders of the echelle grating. The useful zone of the mask is approximatively 13 x 70 mm. The calibration of the focal surface and the drawing of the work was done using the OPTRONICS two-coordinate microphotometer of the ESO Sky Atlas Laboratory. A small modification of the microphotometer allows it to be used in play-back mode to make a negative on a high-resolution photographic plate. A negative copy of this plate gives us the mask which in fact is a glass plate coated with chrome.

Measurements of the sky light from the laboratory permit a partial test of the mask. The correlation dip for the Sun is characterized by a 15 km/s width at half depth. The daily variation of the solar radial velocity (0.3 km/s at Geneva) is easily measured with a scatter of ± 0.1 km/s for the individual measurements. Tests on stars other than the Sun are planned during the next few weeks and will be the subject of another report.

An observation period at La Silla is planned after some months of observing in the northern hemisphere.

Of Apollos and Trojans

It is often seen in science that more is learned from abnormal ("pathological") cases than from the normal ones. This is certainly true in astronomy too.

The title of this note should not confuse the reader. We do not attempt to discuss the mentality or health of ancient Greek gods and warriors, but rather to summarize some new information pertaining to these two "families" of minor planets which has recently become available from observations with ESO telescopes. They represent extremes in the asteroid world: the Apollo planets are those which come closest to the Earth; the Trojans are more distant than any other known minor planets.

1976 WA

Comparatively few Apollo asteroids are known to date. The most famous, (1566) Icarus, comes within 28 million kilometres from the Sun, in a very elongated orbit that also carries it across the Earth's orbit. The interest in these rare objects has recently increased considerably after the discovery of not less than four new Apollos within a span of only 11 months. Two were discovered late in 1975 at the Palomar Observatory (1976 AA and 1976 YA), the third in October 1976, also at Palomar (1976 UA, cf. THE MESSENGER No. 7, p. 5) and the fourth, 1976 WA, was the first one found by the ESO Schmidt telescope for which a reliable orbit was also established.

1976 WA is another by-product of the ESO (B) Survey of the Southern Sky. It was discovered by Dr. H.-E. Schuster on a 60-min plate taken for this survey on November 19, 1976 as an unusually long trail. Further plates were obtained on the following nights, and after accurate positions had been measured, Dr. B. Marsden was able to calculate the orbit on December 6. Observations by Dr. E. Roemer with the 229-cm telescope of the Steward Observatory, situated at Kitt Peak, improved the orbit, and it was found that this new Apollo-type planet passed only 20 million kilometres from the Earth on October 3.

From its apparent magnitude, the size of 1976 WA is estimated to be 1–1.5 km. Its orbit is extremely elongated (the fourth most elongated known!) and it moves between 124 million and 598 million kilometres from the Sun, i.e. going well beyond the orbit of Mars while almost touching that of Venus.

1976 UQ and 1976 UW

Some weeks before the discovery of 1976 WA, a small observational programme was carried out with the ESO Schmidt telescope, the aim of which was to search systematically for new Apollo asteroids. This programme was proposed by Dr. L. Kohoutek of the Hamburg Observatory, who may be more known for the comets he has discovered than for the many minor planets he also has to his credit.

Dr. Kohoutek reasoned that, in order to increase the chance of discovering Apollo objects in the vicinity of the Earth's orbit, one must look along this orbit. Other considerations show that the chances are even better if one looks slightly inside the Earth's orbit, at about 80° elongation from the Sun. This is shown in the figure.

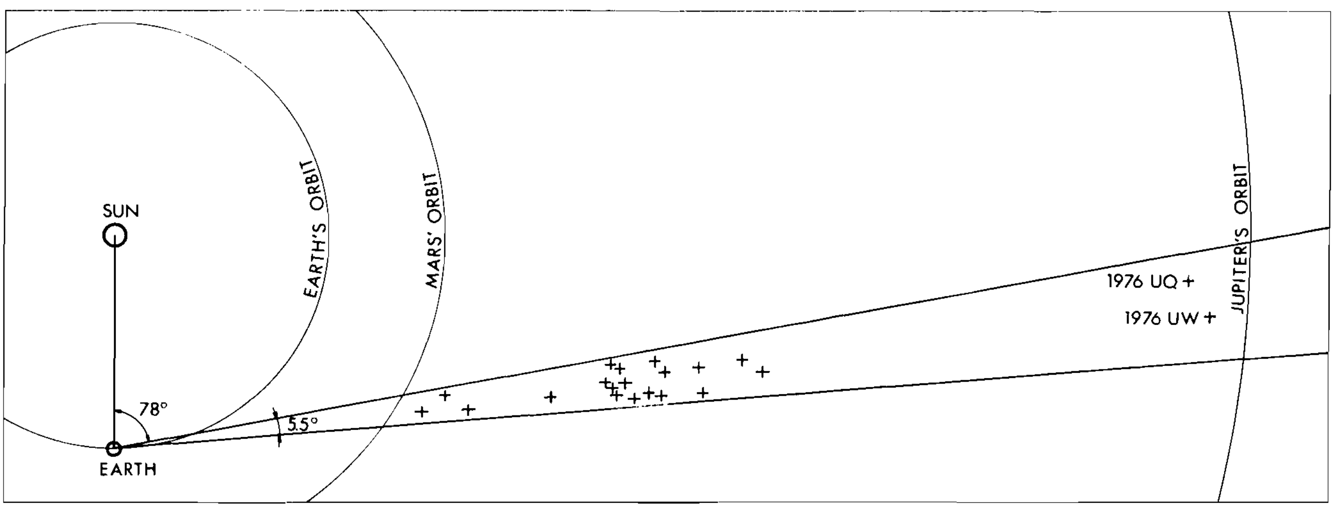
Schmidt plates were taken in this direction towards the end of October by Dr. R. M. West, assisted by Guido Pizarro. The weather could have been better, but six plates were obtained during a period of ten nights. The plates were "blinked" (intercompared in a special machine that allows the operator to see first one plate and then another, so that the image of any moving object will appear to jump back and forth when switching from one plate to the other) and the positions of twenty-seven minor planets that were seen on the plates could thereafter be measured on the ESO S-3000 measuring machine in Geneva.

This material was transmitted to Dr. Marsden at the Smithsonian Observatory in Cambridge on November 12, and by hard work he was able to calculate preliminary orbits for all 27 objects within a few days. Checking with already known asteroids, he found that two of the planets were identical with (1069) Planckia and (1881) Shao, but that the other twenty-five were all new discoveries.

With a time span of only ten days, these orbits could of course not be very precise, and some were somewhat indeterminate. But one conclusion could be drawn: there were *no* new Apollo-type asteroids among the twenty-five! However, to some surprise, two of the new asteroids turned out to be new Trojans, at distances of close to 750 million kilometres from the Earth. A strange paradox: you look for the close and you find the distant.

On the basis of Dr. Marsden's orbits, the ephemerides (expected positions) were computed and the most interesting asteroids could be refound and observed until the end of January 1977. It has now been confirmed that none are Apollos, and that 1976 UQ and 1976 UW may definitely be added to the small list of minor planets, carrying the names of hero-warriors and other persons involved in the siege of Troy. It even turns out that 1976 UQ has the highest known orbital inclination among Trojans, 39°, which also happens to be the fifth highest inclination among all (2,000 or so) minor planets with well-known orbits.

Like the other Trojans, the two new planets are bound to follow orbits that are determined by the combined gravitational field of the Sun and Jupiter. The orbital periods are close to that of Jupiter, approximately 12 years.



Geometry of the ESO "Apollo" programme, end of October. The field of the Schmidt plates has been indicated (5°5) as well as the positions of twenty-one new minor planets for which the distance from the Earth could be computed. The two new Trojan planets, 1976 UQ and 1976 UW, are close to the orbit of Jupiter. Note how the asteroids cluster at particular distances.

X-ray Sources in Cluster of Galaxies

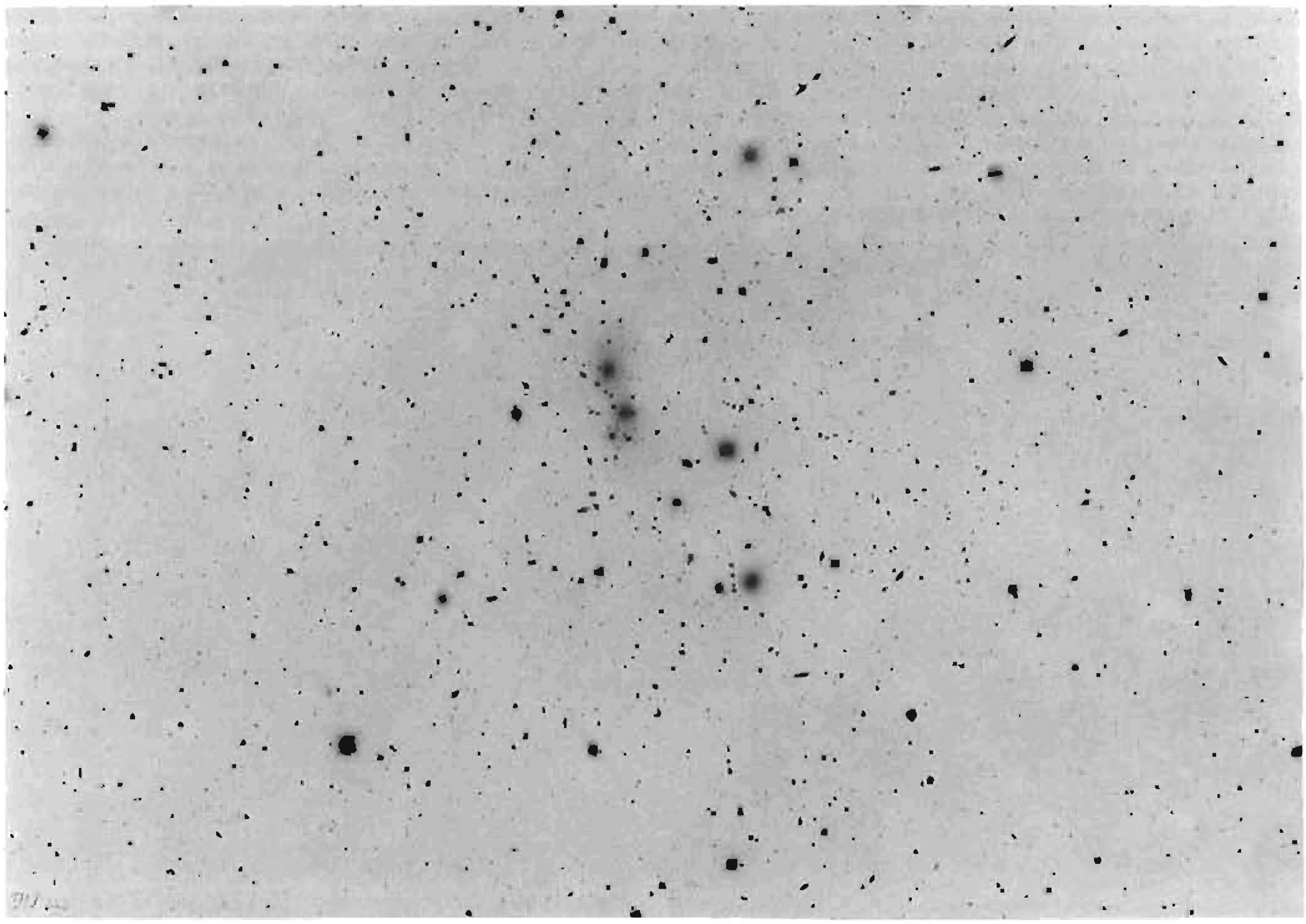
Dr. R. Havlen (ESO staff astronomer in Chile) and Dr. H. Quintana (former ESO fellow in Geneva, now with NRAO, Charlottesville, Virginia, USA) recently undertook a thorough study of the southern X-ray cluster of galaxies CA 0340 – 538. Ever since satellites with sensitive X-ray detectors first showed the presence of strong X-ray sources near the centres of rich clusters of galaxies, astronomers have been asking: why and how? Some even think that high-energy astrophysics has never had as fascinating a subject for study as the central regions of X-ray clusters. Here, as in any other field of astronomy, observations are of paramount importance. Drs. Havlen and Quintana introduce the new field and explain their programme:

The general concepts and questions concerning clusters of galaxies were discussed in the September 1976 issue (No. 6) by Dr. Jürgen Materne. Here, we want to summarize one aspect of clusters of galaxies, i.e. the X-ray emission by some of them, and briefly describe one interesting example being studied at ESO.

Rich clusters of galaxies, typically containing up to thousands of members, are often observed as powerful emitters of X-rays by the various satellites now devoted to X-ray astronomy. Some other extragalactic objects are also observed in X-rays. Some QSOs, Seyfert galaxies and other active objects are detected, but all of them appear to be compact and sometimes variable. Cluster X-ray sources have an appreciable size, being one or two million light-years in diameter. It is conjectured that the X-ray radiation in these sources is nothing else but the thermal radiation of a very hot, tenuous gas (at a temperature of a hundred million degrees) that would fill the inner regions of the clusters, being invisible on photographic plates. It is an open question at this time as to what would be the origin of such a gas. Would it be the remnant of the primordial, unprocessed, material of the Universe, i.e. a mixture of hydrogen and helium only? Or would it be material coming out of the galaxies themselves or some combination of these two possibilities?

Since the mass present in gas is not bigger than the mass in the galaxies, none of the above possibilities is excluded a priori. If this question is answered, there remains the problem of what is the heating mechanism in operation. The possible detection of iron lines in the X-ray spectrum of the Perseus cluster very recently by the Ariel satellite would indicate the presence of material originating in the galaxies, if confirmed. At least part of the gas would have been processed in stars that produce the metals.

Due to the limited sensitivity of the detectors in X-ray satellites, only one or two dozen cluster sources have been



Central region of the cluster CA 0340 – 538. Deep IIIa-J plate taken in the prime focus of the 4-metre telescope at the Cerro Tololo Inter-american Observatory by Dr. J. Graham. Note the three giant elliptical galaxies.

detected. It is important to identify these sources to study the optical clusters in detail. In 1958, George Abell compiled a catalogue of all the rich clusters (down to a certain magnitude) that appear on the Palomar Sky Survey, i.e. in the northern hemisphere to $\delta \approx -20°$. This list has helped astronomers to identify X-ray clusters in that area of the sky, but in the south this task has been rather slow. With the ESO/SRC sky survey in progress, today the job is easier.

Plate collections of the southern skies were searched for X-ray cluster identifications. One of them was the proper-motion plate collection of the University of Chile taken with the Maksutov camera at Cerro El Roble between 1968 and 1973. On positional agreement (sometimes rather poor because the X-ray error boxes were big) some identifications were suggested based on this material and the 3 UHURU catalogue of X-ray sources (Jorge Melnick and Hernan Quintana, *Astrophysical Journal* 198, L 97, 1975).

The Ariel 5 satellite has recently confirmed one of the suggested interpretations (J. P. Pye and B. A. Cooke: *Monthly Notices* 177, 21 P, 1976). The source 3U 0328 – 52 lies within an area of 18 square degrees that includes three rich clusters of galaxies, but one of them appears as the likely source because of morphological reasons. The source detected by Ariel 5 has a much more precise position and coincides with the proposed cluster: CA 0340 – 538. This fairly spherical cluster contains many hundreds of galaxies, mostly ellipticals concentrated towards the centre, and has three giant ellipticals which show extended halos. Previous examples of such galaxies in clusters appear isolated or in pairs (see photo of the cluster).

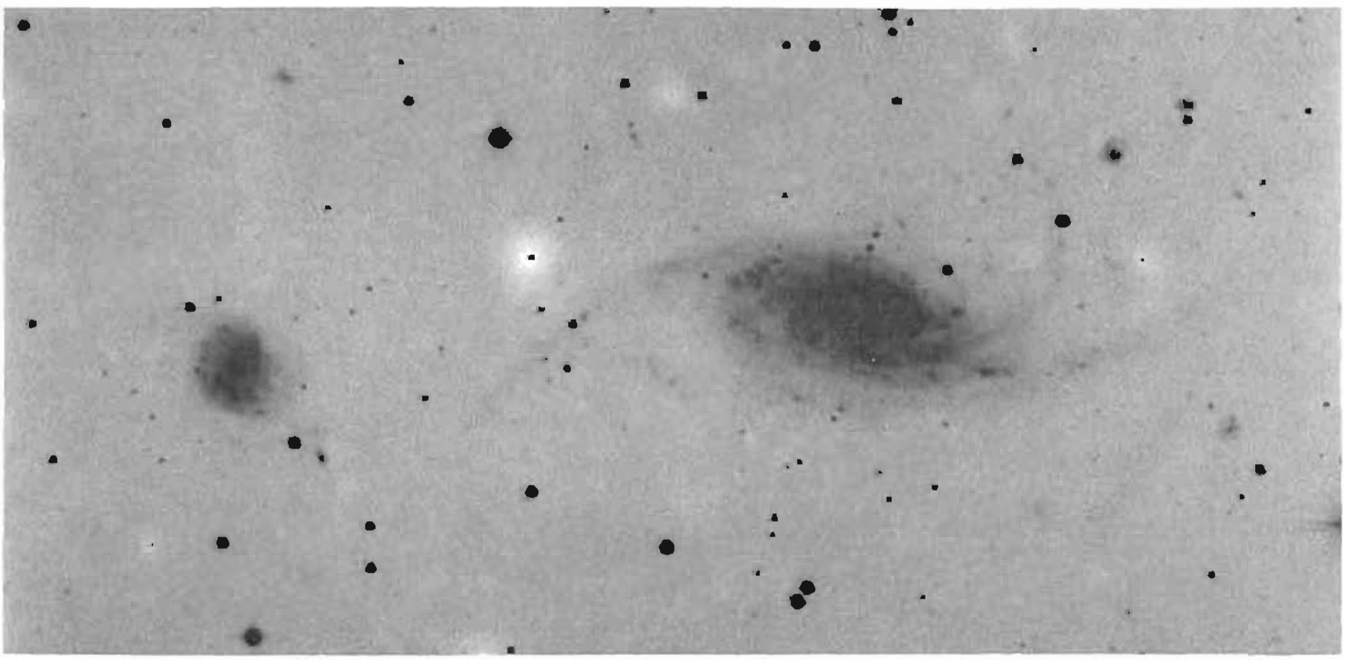
A programme was started at ESO to study this interesting cluster. Radial velocities have been determined for a number of galaxies using the 152-cm telescope. In this way a velocity dispersion can be estimated. A photometric study is in progress, comprising both photoelectric photometry and measures of direct plates using the PDS densitometer at the Nice Observatory. Also, a study of the morphology and distribution of the various galaxy types throughout the cluster is being carried out from plates taken with the ESO Schmidt telescope at La Silla. All this information, when combined with the X-ray data, is expected to restrict the types of models that can be constructed to explain the origin of the intracluster gas and its heating mechanism. Because the answer will bear on the evolutionary history of the clusters and their formation, one hopes to approach a solution to the problem of the "missing mass".

Spectroscopic Observations of Galaxies in the ESO/Uppsala Lists

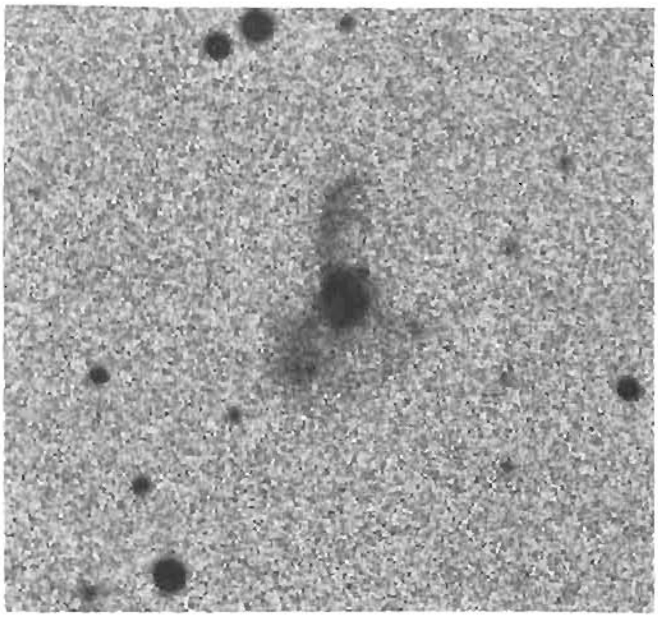
In the June 1976 issue of THE MESSENGER (No. 5, p. 5), we reported on the joint ESO/Uppsala programme, the aim of which is to establish a catalogue of conspicuous objects on the ESO (B) plates. Since that time good progress has been made and about 300 fields (or half of the ESO (B) Atlas) have now been searched. Approximately 9,000 objects have been listed; just recently, the fourth ESO/Uppsala list was published in the *Astronomy & Astrophysics Supplement Series* (Holmberg *et al.*, 27, 295).

There is no doubt that many southern astronomers have already made efficient use of these lists as a basis for their observing programmes. In the southernmost fields, more than 70 % of the listed objects are new. Most are galaxies and a large number of potentially "interesting" ones (interacting, peculiar, etc.) are found in the lists.

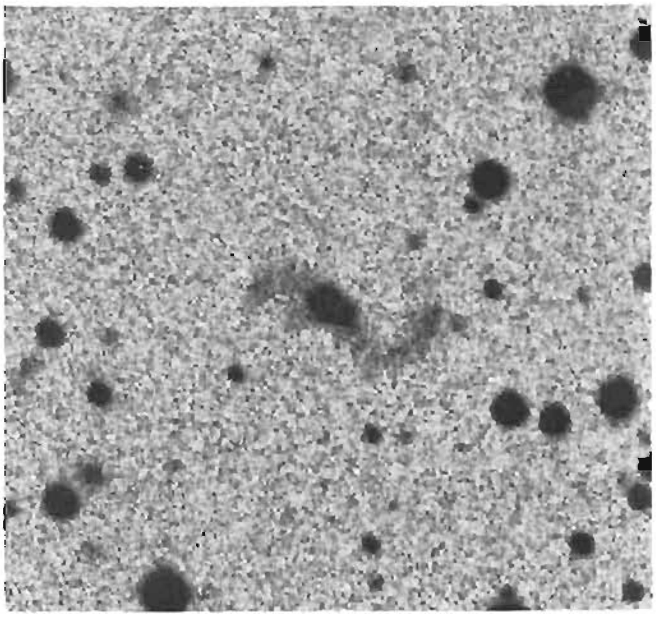
In order to exploit optimally this extremely "rich" material, a systematic approach is desirable. In addition to American astronomers at the Cerro Tololo Interamerican



Interacting system ESO 122-IG01/IG02. On this photo, obtained with the ESO 3.6-metre telescope on November 24, 1977, one may clearly see a "bridge" connecting the larger galaxy (IG01) with the smaller (IG02). The system resembles to some extent the much brighter M51 system. The distance is about 45 Mpc and both components show emission lines. (Plate 110, 90 min exposure, IIIa-J + GG 385; observer Dr. H.-E. Schuster.)



ESO 148-IG02. A new galaxy of Seyfert class 2. The measured velocity is V_0 13,270 km/s; M_v $22^m.5$. Largest diameter 76 kpc (with H_0 55 km/s/Mpc). Note the wispy "arms" extending from the nucleus. ESO Schmidt telescope, 60 min, IIa-O - GG 385.



ESO 184-IG65. A supergiant galaxy with a very bright nucleus and two opposite arms. Largest diameter (from tip to tip) 100 kpc, V_0 - 18,500 km/s. On the original ESO Schmidt plate, the West arm (to the right) may be traced far to the North, indicating an even larger size of this galaxy. ESO Schmidt telescope, 60 min, IIa-O · GG 385.

Observatory and British/Australian astronomers at Siding Spring, astronomers in the ESO member countries are now beginning to observe the ESO/Uppsala objects. This note describes the progress in another joint ESO/Uppsala "spin-off" project: the spectroscopic investigation of peculiar and interacting galaxies from the mentioned lists.

Two teams of astronomers from Uppsala (Drs. Bergvall, Ekman, Lauberts and Westerlund) and ESO (Drs. Breysacher, Muller, Schuster and West) have made spectroscopic and photometric observations of more than 150 galaxies during the past twelve months. The basic observing list was established in Uppsala, by Lauberts and Westerlund, and includes several hundred galaxies, most of which are apparently abnormal in some way (distorted, relatively bright nucleus, interacting with neighbouring galaxy, etc.). The aim of the ESO/Uppsala astronomers is to obtain physical information about these peculiar galaxies, in particular to measure the radial velocities and to discover the systems with strong emission lines. Galaxies that turn out to be especially interesting (Seyferts, etc.) may then later be further investigated with a large telescope in order to obtain a fuller astrophysical understanding of the processes going on in their interiors.

Spectra have been taken with the ESO 1.5-metre telescope on La Silla and the ESO Boller & Chivens image-tube spectrograph with a dispersion of 254 Å/mm (spectral region 3500–5500 Å). These spectra show clearly the H and K lines in absorption for most galaxies, and quite often also a strong G-band at 4300 Å. For the galaxies with emission lines, the 3727 Å [O II], the 5007 Å and 4959 Å [O III], and the hydrogen lines (Hβ, Hγ, ...), are within the observed spectral region. Many spectra were also obtained with the Carnegie image-tube spectrograph attached to the 1-m Las Campanas telescope. The necessary observing time was kindly made available by the Carnegie Institution of Washington and the Director of the Las Campanas Observatory, Dr. H. Babcock. These spectra were of a similar dispersion, 284 Å/mm, but cover a somewhat broader part of the spectrum (3600–7500 Å). Whenever emission is present, the line at 6562 Å, and frequently the [S II] and [N II] lines in the red as well. A higher dispersion (135 Å/mm) was used for a number of galaxies with strong emission lines.

A large number of the objects in the ESO/Uppsala observing list have turned out to be of great astrophysical interest. Among the 150 first observed, about 50 % showed emission lines, and about thirty very strong lines. Many had broad lines, and about ten may be classified as of Seyfert class 2. Of the observed galaxy pairs, most had similar velocity. In several groups of galaxies, all components have emission lines. A number of supergiant galaxies (diameters around 100 kpc) were found. The illustrations show some of these cases.

In order to estimate the absolute magnitudes, UBV photometry was carried out with the ESO 1-m photoelectric telescope. So far, more than forty galaxies have been observed, and observing time has been made available for the ESO/Uppsala team in period 19 (April–September 1977). Some of the emission-line galaxies are rather bright, with $M_v \sim$ 23^m.

The observations continue and the astronomers involved have—naturally—decided that the results shall be made available to all interested parties as soon as possible after the observing runs. Several papers have already been published (*Astron. & Astrophys.* 46 (327), 53 (435), *A&A Suppl. Ser.* 27 (73)) and more are in preparation. Those who want to learn the latest status of the project should write to either Dr. A. Lauberts, Uppsala Observatory, Uppsala, Sweden, or Dr. R. West, ESO, c/o CERN, CH-1211 Geneva 23, Switzerland.

All those involved in this project are looking forward to the day when the ESO 3.6-m telescope will be available with a spectrum scanner for further studies of the "best" galaxies. The ESO/Uppsala programme is a classical illustration of practical astronomical research: discovery of the objects with a wide-angle photographic instrument (the ESO 1-metre Schmidt telescope), preliminary spectroscopic investigation for further selection, and finally the detailed study with a large, powerful telescope. At the same time, there are signs that several other astronomers in the ESO member countries are becoming interested in similar, extragalactic programmes and will soon make parallel contributions to the study of our exciting Universe.

Fast Photometry

M. J. Disney

A photon carries only four separate pieces of information: a direction, an energy, a polarization and a time of arrival in our detector. Of these four the easiest to measure is the last, and yet accurate timing has been, for reasons good and bad, sadly neglected. Nowadays, with relatively simple equipment, it is possible to do photometry with much higher timing precision than astronomers have generally used before. Nature so often provides surprises for those willing and able to push measurement into a new domain, that on grounds of principle alone fast photometry deserves much more of our attention.

It is a task of theory to stimulate experiment and yet, as in the case of rapid time-scale phenomena in astrophysics, it often acts in the contrary sense. It has been argued that since τ, the dynamical time-scale for gravitationally dominated bodies $\sim (G\varrho)^{-\frac{1}{2}}$ then τ (star) $\sim$ 1 hour and τ (galaxy) $\sim 10^7$ years, so that measurements on a time-scale of less than τ are a waste of time: probably this has something to do with neglect of the subject in the past.

Dr. M. Disney of the Royal Greenwich Observatory is currently visiting the ESO Scientific Group in Geneva. He has worked in Europe, the USA and Australia on a variety of problems in galactic and extragalactic astronomy. He is a codiscoverer of the only optical pulsar known, that in the Crab nebula. He is, however, together with his colleagues at the Anglo-Australian 3.9-metre telescope, in hot pursuit of other optical pulsars, and one may hope that it will not be long before more may be added to the list.

The 5-minute oscillations in the Sun were discovered only recently, while the rapid optical fluctuations in N galaxies, pulsars, BL Lacs and X-ray sources have been forced on our attention by observations made in non-optical regions of the spectrum. It is time we started to make systematic surveys of similar and related phenomena for ourselves.

The apparatus required can be as simple or as complex as one can afford. The basic requirements, besides the photometer, are an accumulator, a clock and an output device. Thanks to Planck the photons arrive in a handily digitized form (the important number to remember is that a 0^m star provides 1,000 photons sec^{-1} cm^{-2} Å^{-1} band-pass in the visual at the Earth's surface), so the accumulator can be a fast counter which, at a signal from the clock, discharges its output onto a paper-type which can later be analysed. A much faster system can be constructed around a commercial stereo tape-recorder: the individual photoelectron pulses are amplified and recorded on one channel while timing pulses from the clock are recorded on the other. The data can afterwards be transformed to digital form, using a phase-locked loop or electronic flywheel to guard against dropping the odd timing pulse. The system is limited by the band-pass of the tape-recorder, and a better if more expensive approach is to write directly, or via a scaler, onto digital magnetic tape.

Whenever a minicomputer is available in the dome, a much more flexible real-time system can be built. If periodic variations are suspected, the signal can either be folded at some predetermined frequency (as in the case of radiopulsars of known period) or analysed for periodicity using a Fast Fourier Transform algorithm. Such a system was used (Fig. 1) to discover the first optical pulsar, NP 0532 in the Crab, with the 36" at Steward Observatory (Cocke, Disney and Taylor, *Nature,* **221,** 525, 1969). As minicomputers are becoming common user instruments in most domes, this is a system with a good deal of appeal.

For high-precision measurements, such as the search for very faint pulsars, where it is necessary to maintain timing accuracy of a millisecond or so over hours or even days, the clock needs a highly stable oscillator, and it may even be necessary to adjust it frequently by reference to one of the specially broadcast radio signals such as WWB. The adjustments that have to be made for Doppler effects due to the Earth's orbital und diurnal motion can be effected quite easily with the computer. The sensitivity of the system to poor photometric conditions can be radically reduced if a two-channel photometer is used with one channel on the programme star and the other monitoring some convenient star close by in the field.

As you might expect, there are pitfalls. Negative results are worthless unless the system has a demonstrated performance on known sources such as the Crab pulsar or DQ Her. Conversely, it is easy to pick up false signals from TV stations, ground loops and other sources of interference. And there are subtler effects. Strong pulsations were once detected from the nucleus of the Andromeda galaxy. Excitement was damped when it was afterwards found that the period corresponded exactly to one of the cogwheel periods in the telescope drive train. However, with a little care beforehand and a little caution afterwards most of those difficulties are overcome.

The real challenge in this subject, as in all observational astronomy, is not so much *how* to look but *where* to look. With so many possibilities open I hesitate to even suggest a strategy. Given sufficient time on a small telescope (≦ 20 cm) a random browse through the Yale catalogue might prove very rewarding. Such a project might appeal to the well-equipped amateur or the small professional observatory.

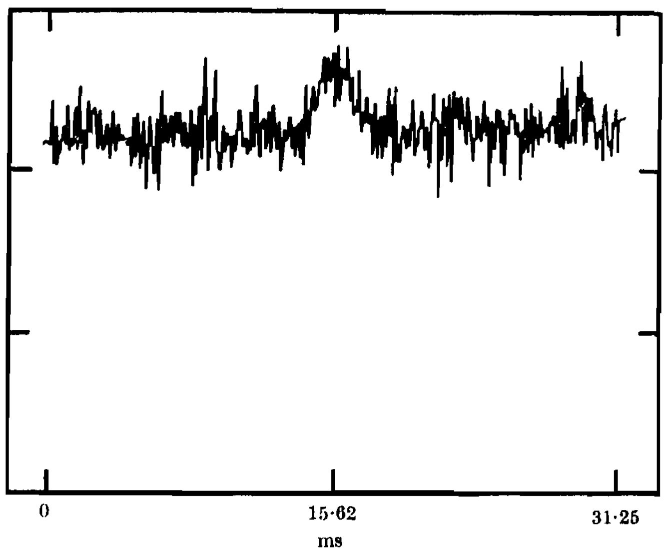


Fig. 1. — *The light-curve of the Crab pulsar as first seen in 1969. A minicomputer attached to a 36" telescope was used to fold the photon pulses in real time at the radio period of 33 milliseconds. Observers could watch the pulse appearing out of the noise on a cathode ray tube.*

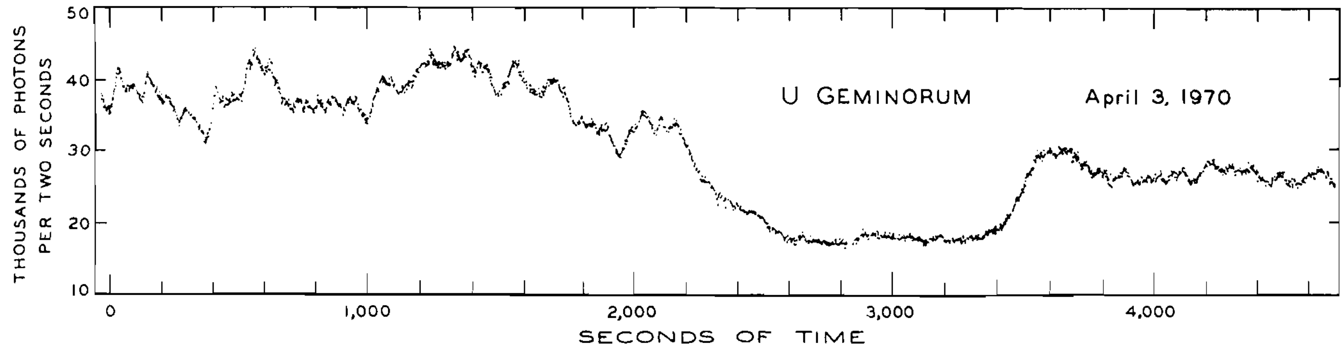


Fig. 2. — *The rapid flickering of the dwarf nova U Gem as measured by Warner and Nather. The flickering comes from a small spot where accreted material from a companion falls onto a white dwarf. Note that flickering stops during the eclipse.*

For the professional who must justify his observing requests on larger telescopes with at least some probability of success, one can pick four or five promising lines:

(a) Extragalactic pulsars: Radio pulses are smeared out or dispersed by electrons along the line of sight. This dispersion makes detection at great distances increasingly difficult and it may be impossible to *find* extragalactic pulsars in the radio without a prior knowledge of the period. Optical pulses are not dispersed and a survey of extragalactic supernovae might result in success. Previous observations suggest that a pulsar's optical luminosity falls off with a very high power ($\geqq 8$) of the period, and hence with the age. Young pulsars could therefore be very luminous and detectable out to tens of megaparsecs with a large telescope. The supernova envelopes will probably remain optically thick for some months after the explosion, so a guesstimate is necessary of the optimum time to search. The real goal is to measure the intergalactic electron density along the line of sight for, with a knowledge of the optical period, radio astronomers should then be able to detect the pulsar and measure its dispersion.

(b) Stellar black holes present an interesting challenge. Their time-scale $\tau \sim GM/c^3 \sim$ milliseconds. A 1-metre telescope should detect $\sim$ 400 photons/millisecond from a possible 10^m black hole, so the detection of the irregular fast flickering that should be a signature of these objects is possible. X-ray binaries like Cyg X-1 are a good place to start.

(c) If experience with Uhuru is anything to go by, the large expansion of X-ray astronomy which the HEOs will bring in the next years should provide a rich harvest for the fast photometrist. The accretion of gas onto degenerate stars ($\tau \sim 10$ to 10^{-3} sec) and black holes (10^{-3} to 10^{-4} sec) implies short-time-scale phenomena, and of course many sources, like the X-ray pulsar Her X-1, have proved to be equally active in the optical.

(d) Cataclysmic variables (novae) clearly display the accretion processes thought to be responsible for the X-ray binaries. In a beautiful series of observations (see Fig. 2) Warner and his colleagues (*Sky & Telescope*, **43**, 82, 1972) have unlocked many of the secrets of these systems, but much remains to be done.

(e) The fastest variations in the extraordinary objects in the nuclei of galaxies, BL Lacs and QSOs place very strong constraints on the physical processes involved (Elliot & Shapiro, 1974, Ap. J., 192, L3). The faster the variation the smaller the object. For a given size, virtually any model will have an upper luminosity limit, and by comparing prediction with observation, many models can be eliminated. In the case of BL Lacs, variations of a few per cent in times of minutes have been reported and there are tantalizing but unconfirmed hints that very fast (10 sec) 50 per cent bursts may occur. Of all the suggested models, only a black hole could accommodate these bursts.

Fast photometry has a short but interesting history and a very exciting future. For a modest cost, say $25,000, a transportable real-time system can be built to use with telescopes both large and small, and it is to be hoped that European astronometry will play an active role in these developments.

STAFF MOVEMENTS

Since the last issue of THE MESSENGER, the following staff movements have taken place:

ARRIVALS

Munich
None

Geneva
Marie Hélène Ulrich, French, astronomer

Chile
None

DEPARTURES

Munich
None

Geneva
Susanne Negre, German, administrative assistant

Chile
Marcel Moortgat, Belgian, technical assistant (mech.)

TRANSFERS

André Muller, Dutch, senior astronomer (from Munich to La Silla)

FELLOWS AND PAID ASSOCIATES

The following astronomers have taken up or will soon take up work as fellows or paid associates at the Scientific Group in Geneva:

Tenguiz Borchkhadze, Russian (Dec. 1, 1976–May 31, 1977)
Jan Lub, Dutch (from Jan. 1, 1977)
Per Olof Lindblad, Swedish (from Jan. 1, 1977)
Michel Disney, British (Jan. 15–April 15, 1977)
Jorge Melnick, Chilean (from March 1, 1977)
Sandro D'Odorico, Italian (March 15–May 15, 1977)
Piero Salinari, Italian (from April 1, 1977)

Observations at La Silla of Peculiar Emission-Line Objects with Infrared Excesses

Jean-Pierre Swings

HD 45677 may be considered the prototype for these peculiar emission-line stars that are now called B[e]'s, i.e. Be stars whose spectra exhibit forbidden lines as well as permitted lines of H, Fe II, ... HD 45677 has the following coordinates: $\alpha = 6^h26^m$ and $\delta \approx -13°$. It is therefore ideally located to be observed from La Silla during the summer or early fall in the southern hemisphere. In other words at epochs when the weather is perfect. I should probably mention here that out of the 57 nights that were allocated to me by ESO and by CARSO (ten nights at Las Campanas) between 1972 and 1976, only three could not be used for spectroscopy: that corresponds to a 95 % record!

Dr. J.-P. Swings of the Institut d'Astrophysique of the Liège University studies those rare stars that have emission lines. From an impressive series of observations, carried out in the period 1972–76, important new information has been obtained about the behaviour of dust-shrouded stars. The combination of optical spectroscopy and infrared photometry has allowed a better understanding of the physical processes in these very peculiar objects.

In order to illustrate what is meant by "infrared excess", Fig. 1 reproduces the energy distribution of HD 45677 in the visible and near infrared. For a normal B star the energy should go roughly to zero beyond 1 or 2 microns; on the contrary one clearly sees that in the case shown in Fig. 1 there is a remarkable rise of the energy curve in the near IR, with a maximum somewhere around 5 μ. It is now believed that such a strong infrared excess is to be explained by the presence in the circumstellar environment of solid particles (therefore the expression "dust shell") which absorb the ultraviolet and visible radiations and degrade them to infrared wavelengths. In the case of the prototype HD 45677 one then gets an empirical simple-minded physical model where a dust shell of a radius of about 30 astronomical units, optically thick at 5 μ, surrounds the B[e] star and its extended atmosphere, ring (see Fig. 2), and forbidden line regions. Of course HD 45677 may be regarded as an extreme example of B[e] stars, perhaps even as "an object intermediate between an ordinary Be star and a planetary nebula" using the words of P. Merrill in 1952. This possible

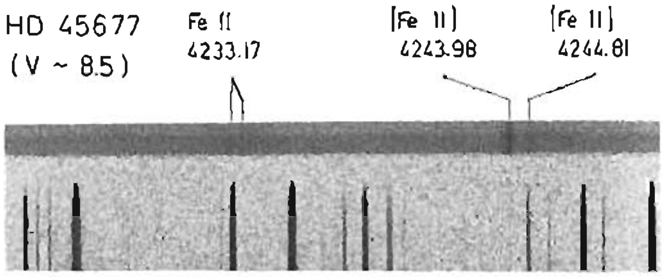


Fig. 2. – *In the spectrum of HD 45677 the Fe II emission line λ 4233.17 Å is double with no central absorption, whereas the [Fe II] emissions (λλ 4243.98 and 4244.81 Å) are single (ESO plate, 1.52-m coudé spectrograph, camera III, i.e. original dispersion 3 Å/mm obtained during a 3-night exposure in Feb. 1972). The author has suggested that the Fe II emissions are produced in a rotating equatorial disk (or ring) surrounding HD 45677. A similar doubling of the Fe II lines was discovered in the spectrum of another southern hemisphere star with IR excess: GG Carinae.*

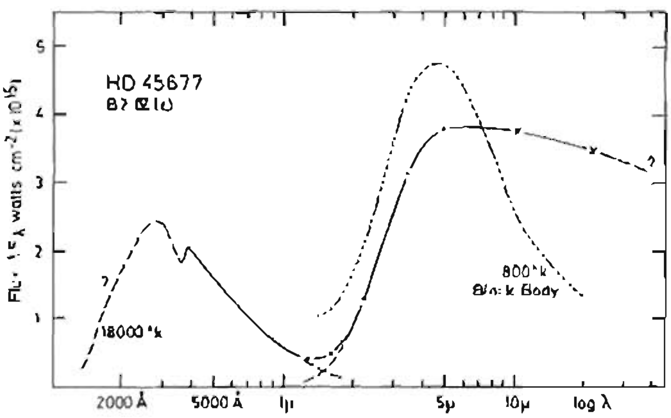


Fig. 1. – *Energy distribution of the B[e] star with strong IR excess HD 45677. Wavelength is plotted logarithmically on the abscissa, and flux linearly on the ordinate: on such a graph the area under a segment of the curve represents the energy radiated in that wavelength interval. An 800°K body, shifted by 10^{-15} W cm^{-2}, is shown for comparison.*

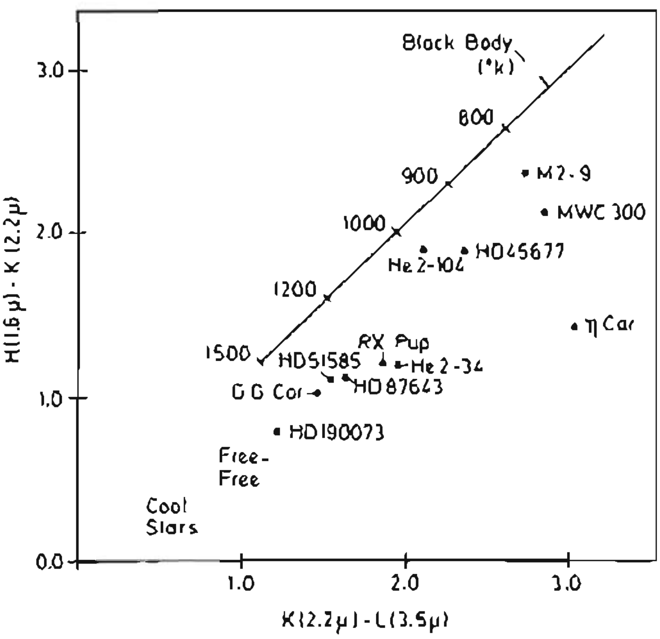


Fig. 3. – *The near IR colours of a few peculiar emission-line objects observable on La Silla are plotted on an H-K/K-L diagram. Temperatures of idealized dust shells are marked along a "black body" line. The locations of normal cool stars and of stars whose IR continuum is due to free-free emission are indicated for comparison.*

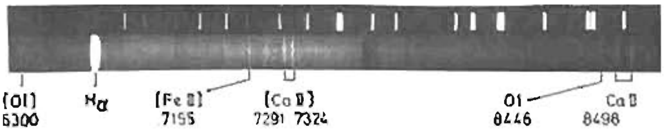


Fig. 4. — The spectrum of RX Puppis from 6300 to 8600 Å obtained with the Boller and Chivens spectrograph at the 1-m telescope (80 Å mm⁻¹).

connection between evolved Be's and young planetary nebulae leads me to introduce an interesting colour-colour diagram on which one may plot the position of emission-line stars with IR excesses: the H (1.6 μ) – K (2.2 μ) versus K – L (3.5 μ) diagram. On such a diagram (see Fig. 3) one sees immediately that the colours of a variety of objects (observable from La Silla) are similar: η Carinae, the well-known nova-like, M 2–9, the "Butterfly nebula", dense planetaries such as He 2–104, B[e] stars like HD 87643 or GG Carinae, an ex-symbiotic star, RX Puppis (Fig. 4). It is interesting to note that the spectra of most of those objects reveal low excitation emission lines of e.g. [O I], [S II], and [Fe II], as pointed out by Dr. David Allen and the author.

The study of the spectra of the peculiar emission-line objects of the southern hemisphere is performed on La Silla with the use of the coudé spectrograph of the 1.52-m telescope and of the Boller and Chivens image-tube spectrograph at the 1-m telescope: it covers the wavelength region between the near UV to about 8600 Å. The reduction of the data is often a collaborative venture between myself and colleagues in Liège such as Miss M. Kluth and Dr. J. Surdej, who is now with ESO in Chile, or students writing a dissertation for their master's degree.

The aims of these investigations are (1) the detection of low excitation emission lines in the spectra of those faint objects for which near infrared photometry has revealed excess continuum radiation (following the correlation mentioned above), (2) the study of the emission-line intensities in order to derive physical parameters concerning the extended atmospheres of the B[e] stars or dense planetaries, (3) the monitoring of line-profile variations such as changes from night to night or during the course of the night in the Balmer lines in HD 45677 and RX Puppis (Fig. 4) or from one observing run to the other in the Fe II lines of GG Carinae that give an idea of what happens in the extended atmosphere around the stars, (4) the study of P Cygni profiles in e.g. HD 87643 or CD –52°9243 (Fig. 5) that should lead to an understanding of how the mass loss occurs in these stars, (5) the structure of emission lines such as Fe II in HD 45677 (Fig. 2) or [O III] in HD 51585 (Fig 6) that give us some indication about the structure and possible heterogeneities in the atmospheres of these stars: in the case of HD 190073 the observation of the evolution of the Ca II complex line profiles can be interpreted in terms of resonance scattering phenomena.

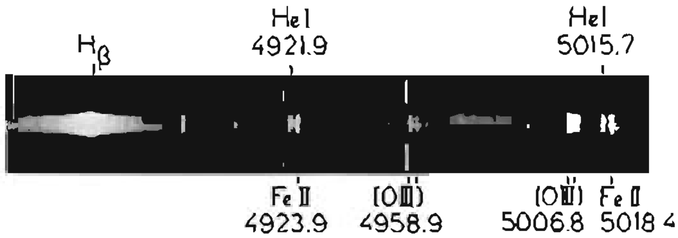


Fig. 6. — The spectrum of HD 51585 in the region of Hβ and [O III] λλ 4959 and 5007 Å (coudé spectrogram, original dispersion 20 Å mm⁻¹). The two [O III] emissions are clearly double, while He I and Fe II lines are single.

It is therefore clear that for peculiar emission-line objects of our galaxy there exist many interesting problems to be tackled on the basis of data gathered, or to be gathered, at the ESO telescopes. The next steps will of course contain the study of peculiar emission-line galaxies with IR excesses as well as the extension of the observations of B[e]'s and planetaries to the near infrared once a spectrograph designed for this spectral region (8000–12000 Å) will become available.

The author is most indebted to ESO since the work very briefly described here could not have been possible without the generous allotment of time on the telescopes at La Silla nor without the help of the staff in Chile, in the offices, in the labs, in the domes and ... in the kitchen!

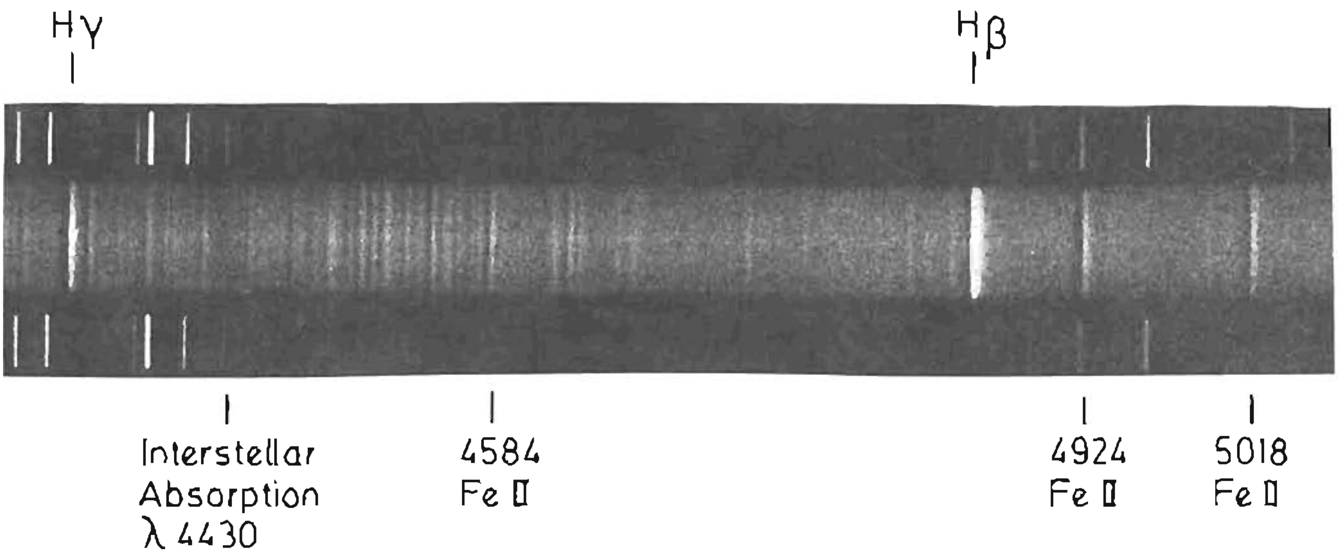


Fig. 5. – Strong P Cygni profiles in the spectrum of CD –52°9243 (original dispersion 40 Å mm⁻¹; Boller and Chivens spectrograph, 1-m telescope).

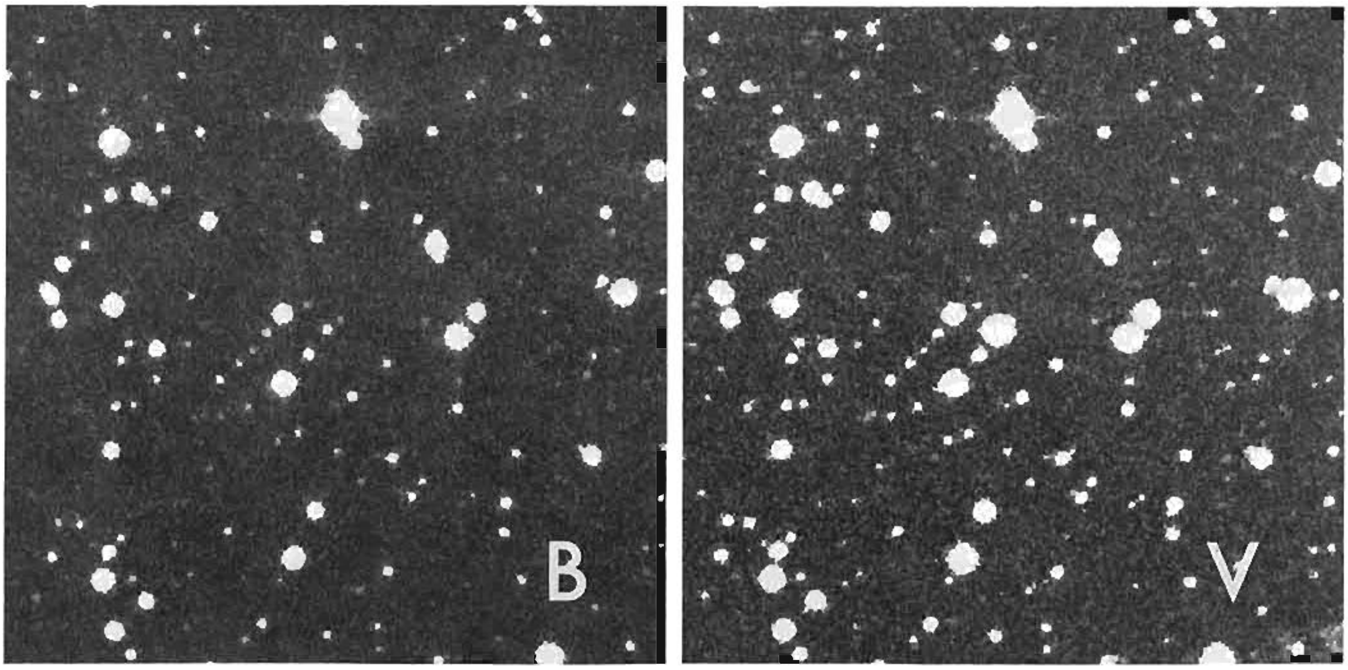
The Sculptor Dwarf Irregular Galaxy and a Large Extragalactic Gas Cloud Detected with the Nançay Radiotelescope

D. Cesarsky, E. Falgarone and J. Lequeux
(Département de Radioastronomie, Observatoire de Meudon)

On the cover of the December 1976 issue of THE MESSENGER was reproduced one of the first photos taken with the new ESO 3.6-m telescope: it represented a dwarf irregular galaxy in the southern constellation Sculptor. This galaxy was named SDIG by Drs. Laustsen, Richter, van der Lans, West and Wilson who reported about its optical properties in *Astronomy & Astrophysics* 54, p. 639 (January 1977). The Messenger photograph clearly shows resolved blue supergiant stars, which allowed the ESO astronomers to estimate the distance of SDIG at about 3 megaparsecs, or 9 million light-years.

On December 1, soon after we heard about this discovery, we looked at the galaxy with the Nançay radiotelescope in the 21-cm line of atomic hydrogen (the radiotelescope can reach declinations as far south as –37°). SDIG was seen at the very first run, with a radial velocity of 220 km/s with respect to the local standard of rest. This radial velocity is just in the range of the velocities of the Sculptor group of galaxies, thus confirming the membership of SDIG to this group and the distance found optically. From our observation, we can estimate the mass of hydrogen in this galaxy, which is of the order of 10^7 times the mass of the Sun. However, the absolute luminosity of SDIG is only 3×10^6 times the luminosity of the Sun. Therefore SDIG must be very rich in gas, probably one of the richest galaxies known today. Other dwarf irregular galaxies usually contain proportionally about 3 to 5 times less gas. It seems that star formation has only just begun in SDIG, or at least that we observe a recent major burst of star formation with little star formation before.

But we were even more surprised when we saw that the 21-cm spectrum showed not only the line emitted by



AN EXTREMELY RED STAR

Compare the two photos above. They are both taken with the ESO Schmidt telescope, the left on December 24, 1976 (IIa-O + GG 385, 30 min) and the right on December 23 (103a-D + GG 495, 40 min). These emulsion/filter combinations mean that the left photo records only blue/violet light and the right yellow/green, or standard colours B and V, respectively. The star in the centre is approximately 4–5 magnitudes brighter in V than in B, i.e. (B–V) ≈ 4–5^m. The position is R. A.= $07^h21^m08^s$; Decl. = –20°59.′2 (1950). The star is seen on the Palomar Atlas; it does not appear to be variable, and it is even brighter in the red.

Few such red stars are actually known. In a recent list (*Astronomy & Astrophysics Supplement Series* 27, 249), two German astronomers, Drs. Weinberger and Poulakos from the Max Planck Institute in Heidelberg, give the coordinates of fifteen stars with (B–V) ≳ 4^m, all of which are far north of the celestial equator. Some of their stars are carbon stars, but others could not be classified.

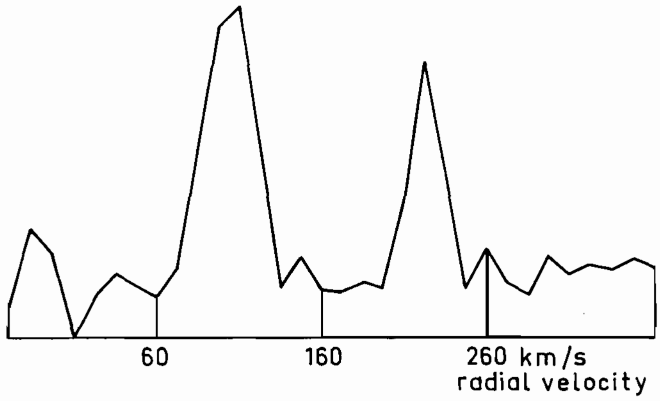
Why is this star so *red*? Is it reddened by interstellar absorption, or is it just very red because of strong molecular bands in its spectrum? Has it emission lines?

We expect to observe the spectrum of this strange object early in March and to inform the readers of THE MESSENGER about the result in the next issue.

SDIG, but another one somewhat stronger, at a velocity of + 100 km/s with respect to the local standard of rest. Further observations have shown that this line comes from a large hydrogen cloud, about 1° in extent, which is in the direction of SDIG but not concentric with the galaxy. We think that this cloud is extragalactic and presumably also belongs to the Sculptor group of galaxies, but this will be hard to prove definitively. In any case, its radial velocity proves that it does not belong to the Magellanic Stream. Radioastronomers had already discovered around the major galaxies of this group, NGC 55 and NGC 300, several such clouds obviously associated with them. Is the new cloud associated with SDIG? We do not know.

The only chance to check this point would be to find some stars possibly formed from the gas of the cloud and to determine the distance of those stars. We have not yet completely mapped the cloud. A provisional estimate of its mass gives some 3 x 10^8 times the mass of the Sun, if the distance is that of the Sculptor group. It seems that we are dealing with a rather massive intergalactic cloud which might be sitting there since the early times of the Universe and has not yet had the opportunity of condensing into stars. There are very few of these objects known today.

This study shows the interest of concerted optical and radio observations. These observations allowed us to find not only a galaxy where only a small amount of gas has been used up to make stars, but also a large mass of gas, where apparently star formation has not yet begun.



21-cm spectrum of SDIG obtained with the Nançay Radiotelescope. At the higher radial velocity, one sees the hydrogen line emitted by SDIG. The line at the lower radial velocities is emitted by an isolated, probably extragalactic, hydrogen cloud which extends over one degree. The radial velocities are relative to the local standard of rest.

Visiting Astronomers

April 1—October 1, 1977

Observing time has now been allocated for period 19 (April 1 to October 1, 1977). As usual, the demand for telescope time was much greater than the time actually available.

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

152-cm Spectrographic Telescope

April: Megessier, Hultqvist, Oyen, Breysacher/Muller/Schuster/West, Schnur, Andersen.

May: Andersen/Nordström, Ahlin, van Dessel, Wamsteker, de Loore, Breysacher/Chu-Kit, Surdej.

June: Gahm, Pedersen, Pakull, Westerlund, Ratier, Terzan, Mauder.

July: Mauder, Ahlin, van den Heuvel/van Paradijs, Materne, Appenzeller/Mundt/Wolf, Houziaux, Rahe.

August: Rahe, Lauterborn, Breysacher/Muller/Schuster/West, Bergvall/Ekman/Lauberts/Westerlund, Surdej, Ahlin, Doazan.

Sept.: Doazan, Collin-Souffrin, Heidmann, Wamsteker, Metz/Pöllitsch, Ahlin, Spite.

100-cm Photometric Telescope

April: Turon, Wamsteker/Schober, Danks/Shaver, Martel, Vogt, Knoechel.

May: Knoechel, Querci, de Loore, Schnur, Vogt, Pedersen.

June: Pedersen, Pakull, Breysacher/Muller/Schuster/West, Westerlund/Wlérick, Alcaíno, Wamsteker.

July: Wamsteker, Mauder, van den Heuvel/van Paradijs, Breysacher/Muller/Schuster/West, Schmidt-Kaler, Wamsteker, Stenholm.

August: Stenholm, Bergvall/Ekman/Lauberts/Westerlund, van Woerden/Danks, Schultz.

Sept.: Schultz, Wamsteker/Schober, Adam, Metz/Pöllitsch, Wamsteker, Wamsteker/Schober.

50-cm Photometric Telescope

April: Megessier, Geyer/Vogt, Lodén, Vogt.

May: Lodén, Knoechel, de Loore, Surdej, Wramdemark.

June: Wramdemark, Gahm, Pakull, Vogt, Elst.

July: Elst, Vogt/Maitzen, Rahe.

August: Rahe, Vogt, Lauterborn, Surdej, Wamsteker/Schober, Doazan.

Sept.: Doazan, Weiss, Spite, Wamsteker/Schober.

Objective Prism Astrograph (GPO)

April to Sept: Blaauw/West, Muller/Schuster/Surdej/West.

60-cm Bochum Telescope

July: Pettersson, Appenzeller/Mundt/Wolf.

August: Pettersson, Reiss, Schober.

Sept.: Schober.

50-cm Danish Telescope

June: Loibl, Sterken.

July: Sterken, Heck, Renson.

Tentative Meeting Schedule

The following dates and locations have been reserved for meetings of the ESO Council and Committees:

March 2	Finance Committee, Garching
April 22	Committee of Council, Garching
May 9/10	*Joint meeting of Scientific Policy Committee and* Instrumentation Committee, Munich
May 12	Council, Munich
May 23–25	Observing Programmes Committee, Kiel

3.6-m Telescope Cassegrain Adapter on La Silla

While this issue of THE MESSENGER goes to press, the Cassegrain adapter is being installed on the ESO 3.6-m telescope. Soon after, the optical tests for the Cassegrain focus will commence, and if all goes well, the first astronomical observations may be made some weeks later.

What will it be like to observe in the Cassegrain cage? We have already assured the future visitors that they will be firmly attached (see THE MESSENGER No. 6, p. 15). This article adds to the picture by describing in some detail the so-called "Cassegrain Adapter", on which all auxiliary instruments to be used in this focus will be mounted. The reader will undoubtedly notice that the text is somewhat more technical than usual in this journal. However, we have felt that it is of importance to those astronomers who are already now planning to use the ESO main telescope to be informed about this adapter as early as possible.

The authors, ESO engineers Sten Milner and Manfred Ziebell, work in Geneva. They have followed the adapter from the earliest design stage to the final tests.

While the year 1976 was characterized by the final construction, erection and first operation of the 3.6-m telescope, it was also the year of manufacture, assembly, mechanical, electronic and optical tests of the Cassegrain instrument adapter for the same telescope.

The provisional tests made at ESO, Geneva, showed satisfactory performance and the adapter was shipped to La Silla on January 20, 1977. The mounting of the adapter onto the telescope started on February 22, 1977.

The adapter shown in Fig. 1 is the mechanical interface between the telescope and the different instruments to be used in the Cassegrain focus. It contains the optical parts and the mechanical facilities required for direct and remote observing of the quality and focussing of the centrefield, and for the spectrometer slit and the guiding of the telescope. The adapter will be mounted directly onto the rear side of the main mirror cell inside the Cassegrain cage, and the control electronics will be installed in one of the four cubicles inside the cage. The adapter will be controlled either by a control panel inside the cage or remotely by the 3.6-m telescope control computer.

The optical path and component location are shown in Fig. 2.

For remote observing, one television camera is installed for centrefield viewing and a second one for guide star observation. The centrefield camera uses an EBS (Electronic Bombarded Silicon Target) tube with an image intensifier in front of the tube. The input window has a diameter of 40 mm. For large-field viewing, the image of a star with a "seeing" of 1" will cover 2 lines and for small-field viewing 16 lines. The estimated limit of sensitivity for large viewing will be in the order of the 17th magnitude on the 3.6-m telescope. To raise the sensitivity of the centrefield, this camera will be replaced by another one with facilities for integration both on the target and in a digital memory.

For guide-star observation, a less expensive television camera with an ISIT -(Intensified Silicon Intensifier Target) tube is used. The estimated sensitivity will be of the order of the 16th magnitude with a resolution of 4.5 lines per arc sec. To begin with, guiding will be carried out manually using the handset. Later on, this TV system will be replaced by an automatic guider.

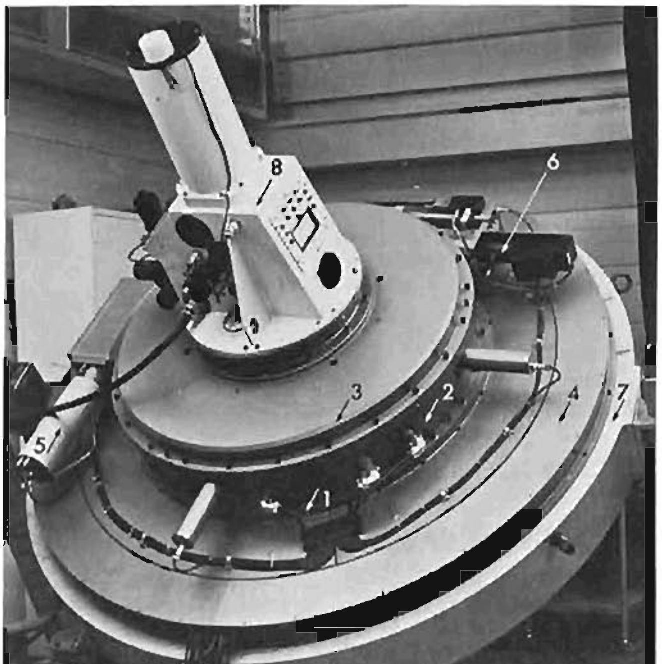


Fig. 1: *CASSEGRAIN INSTRUMENT ADAPTER ON TEST BENCH. — (1) rotator, (2) adapter housing, (3) reduction plate, (4) cable guide, (5) TV camera for centrefield observation, (6) ISIT camera for guiding, (7) test bench, (8) spectrograph.*

Adapter Design

The adapter is divided into 4 mechanical sub-groups. They are: Rotator, Housing, Reduction plate and the Cable guide.

The *rotator* is a large precision roller bearing on which the adapter housing is bolted. The bearing is provided with internal gear teeth and is directly bolted onto the reference plate on the rear side of the mirror cell. It is turned by 3 parallel driven AC motors up to ± 182° from the South direction. The rotation is limited by electrical and mechanical stops. To eliminate the backlash in the gear and any uncontrolled motion during the telescope movement, a special sequence of motor control is used. The angular position is read by an absolute encoder with a resolution of 0°037.

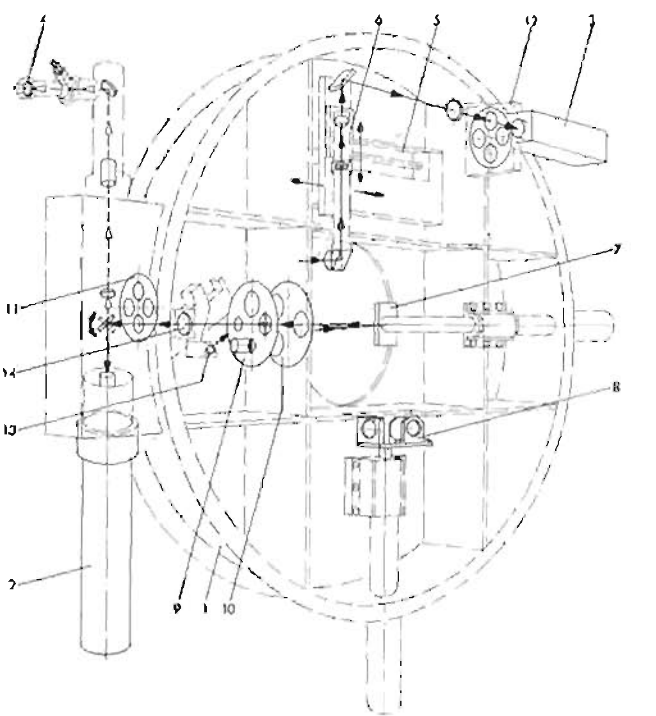


Fig. 2: *SCHEMATIC OF OPTICAL PATHS AND COMPONENT LOCATION. - (1) adapter housing, (2) TV camera for centrefield observation, (3) ISIT camera for guiding, (4) eye-pieces, (5) X-Y displacement table, (6) guide probe with focus-reducer – 90 prism – cross-hair – collimator lens – plane 45°-inclined mirror, (7) centrefield mirror, (8) slit viewing unit, (9) turret for field lenses · cross-hair and knife edge, (10) turret for glass thickness compensation, (11) filter turret for TV camera, (12) filter turret for ISIT camera, (13) small-field objective, (14) large-field objective, (15) plane mirror on pivot for eye-piece or TV observation.*

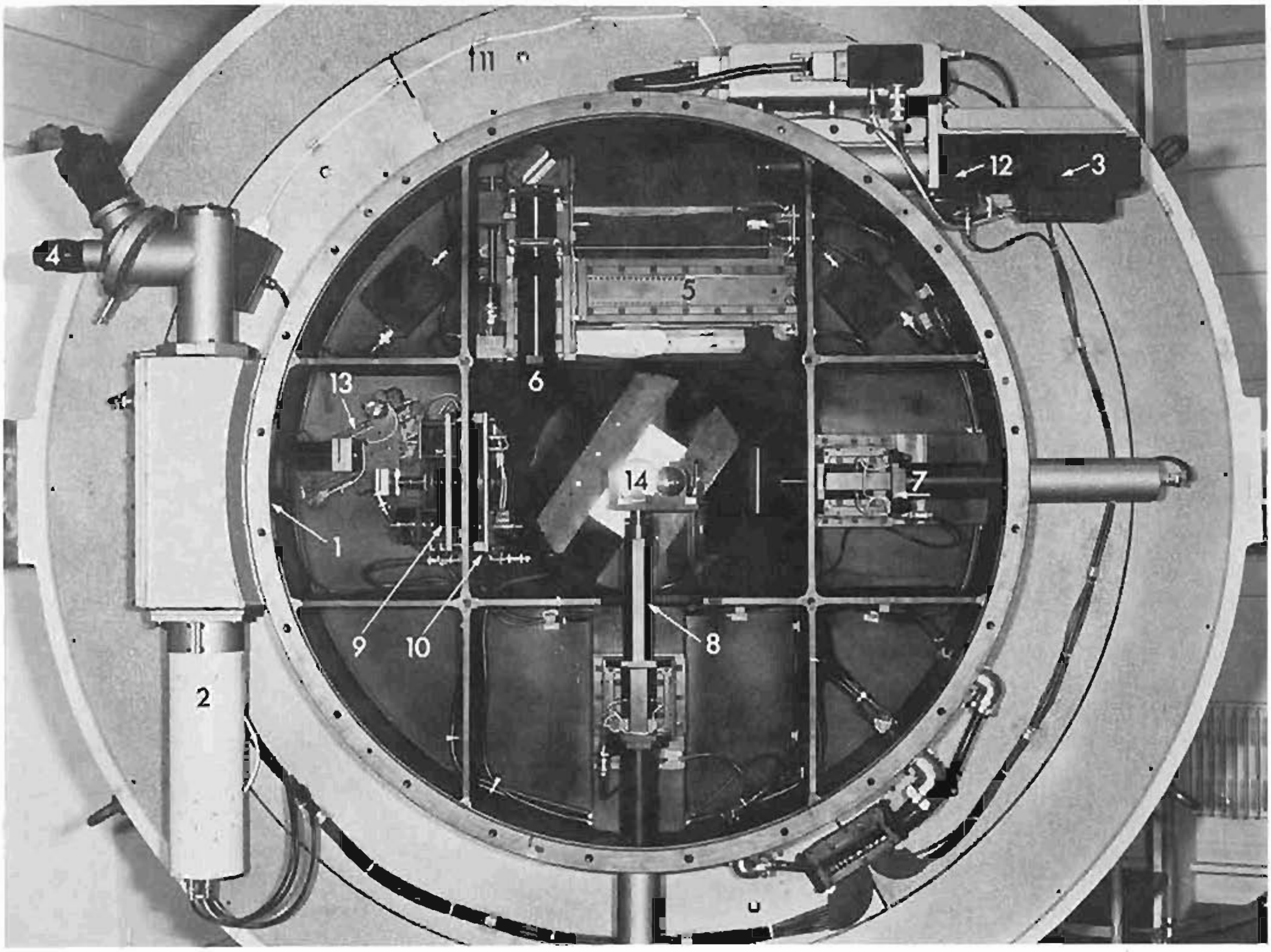


Fig. 3: *ADAPTER HOUSING WITH REMOVED REDUCTION PLATE. – (1) adapter housing, (2) TV camera for centrefield observation, (3) ISIT camera for guiding, (4) eye-pieces, (5) X-Y displacement table with guide probe, (6) guide probe, (7) centrefield mirror actuator, (8) slit viewing unit actuator, (9) turret for field lenses – cross-hair and knife edge, (10) turret for glass thickness compensation, (11) cable guide, (12) filter turret for ISIT camera, (13) carriage for small and large-field objectives, (14) star-simulation device for calibration of the adapter.*

The accuracy of the positioning will be 1/10 of a degree. The bottom face of the bearing is the connection flange for the adapter housing.

The *housing* contains the optical components and related actuating mechanisms as shown in Fig. 3. It is a welded cylindrical steel structure with a plain base plate and 4 strengthening ribs assuring sufficient stiffness to the structure, resulting in less than 5 µm distortion of any reference surfaces of the optical component actuating mechanism, when the housing is tilted from 0 to 45°.

The lower flange end is connected either to a large instrument, such as an echelle spectrograph, or to the *reduction plate* carrying the smaller instruments such as a spectrograph, photometer or camera. The X-Y displacement table positions the guide probe within the area of (308 x 149) mm^2 of the image field, 305 mm from the focal plane. As the adapter can be turned ± 182°, the complete field can be scanned by the guide probe. The X-Y displacement tables are guided in preloaded linear bearings and driven via "play-free" satellite roller screws by means of tachometer DC gear motors. The positions of the tables are given by rotating incremental optical encoders located on the end of the roller screws. The zero position (initialization) is given by a microswitch at the end of the stroke and the first zero pulse of the encoder. The reproducibility of the zero position is 4.2 µm. Within the scanning area the resolution for the guide-probe position is 1.4 µm, the reproducibility will be 5.6 µm and the total accuracy is better than ± 20 µm, deflection included. The time to move the guide probe across the field is 30 sec in X (308 mm) and 15 sec in the Y direction (149 mm). The cables for motors, switches and cross-hair illumination are collected in a cable guide on the side of the X displacement bed. When the adapter is controlled in a manual mode, from the control panel inside the Cassegrain cage, only the speed control feedback loop via the tachogenerator is closed and 2 speeds, fast and slow, are foreseen. The position feedback loop is closed via computer control. When the guide probe reaches its commanded position, the speed is regulated down by computer via a 12 bit D/A convertor.

Two identical actuators support and position the centrefield mirror and slit viewing units in the field with a reproducibility of ±10 µm. The time for displacement (205 mm) from "out" to "in" position is 15 sec. The actuator consists of a ram guided by two recirculating linear bearings engaged in two opposing 90° grooves in the ram. The ram is moved by a screw nut system driven by a DC motor. The "in" and "out" positions of the ram are defined by two mechanical stop plates at the end of the stroke and these positions are indicated by microswitches. The drive motor is controlled by a power amplifier which has, in addition to the negative voltage feedback, a positive current feedback loop to give a negative impedance output characteristic. This is a substitute for tachometer feedback because of less severe requirements for speed stabilization. It functions in the following way: when the friction torque rises, the motor speed will try to go down. The loss of "back-EMF"

New CERN/ESO Telephone Number

As from March 18, 1977 CERN's general telephone number will change from 41 98 11 to 83 61 11.

It will then also be possible for people telephoning from outside CERN to dial the ESO extensions directly, by composing 83 followed by the present internal number. For example:

Scientific Group: (022) 83 50 80
Engineering Group: (022) 83 46 92
Instrumentation Development Group: (022): 83 48 31
Sky Atlas Laboratory: (022) 83 48 34
Geneva Administrative Group: (022) 83 48 38

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 1979 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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will increase the motor current and, because of the positive current feedback, the amplifier will raise the output voltage to stabilize the motor speed. At the "in" position of both actuators, the limit switches are bypassed by a resistor. This drives the ram with reduced torque against the mechanical end stops to increase the reproducibility (± 10 µm). An interlock system insures that only one of the units (slit viewing, centrefield mirror or guide probe) can be moved into the centre of the field at a time.

The turret for the cross-hair, knife edge and the large and small field lenses, positions the first two elements with a reproducibility of ± 10 µm in the focal plane. The position of the wheel is assured by a spring-loaded precision lever, engaging a "play-free" ball-bearing in 4 slots on the periphery of the turret. The time to change from one element to the next is 3 sec. Two microswitches serve for position indication. One switch indicates the zero position and the other one counts the steps from zero to the selected element. As the reduction between the DC motor and the turret wheel is very low, it was necessary to install a circuit with a negative impedance characteristic to achieve sufficient speed control at slow speeds. To change to a new position, the motor is driven for 20 ms with full torque to throw the wheel out of the blocked position (ball-bearing in slot). Then the turret continues turning at slow speed until the next position indicated by the position switch. The same electrical system is used by the turret for thickness compensation, and the two filter turrets for centrefield viewing and the ISIT camera.

The turrets for glass thickness compensation and the two TV filter turrets are built and controlled like the field-lens turret, but less precisely.

The carriage for large and small field-viewing objectives is guided in linear bearings and moved into position by means of a DC gear motor. It is held in the end position by two magnets with a precision of ± 100 µm. The time for full stroke is 15 sec.

The reduction plate is a solid, stabilized steel plate, precision-machined to a planarity of 10 µm of the flanges. The bolt circle diameter of the large flange is 1135 mm, and the internal guide bore 1100 mm. The bolt circle diameter on the small flange is 540 mm and the guiding bore 500 mm. The focal plane is 170 mm from the small flange. The weight of this plate is 500 kg to prevent a serious imbalance in the telescope during a change from a heavy to a light instrument.

ALGUNOS RESUMENES

Fuentes de rayos X en cúmulos de galaxias

Dr. R. Havlen, astrónomo de ESO en Chile, y Dr. H. Quintana, astrónomo chileno empleado por ESO en Ginebra durante 1976, han realizado recientemente un minucioso estudio del cúmulo austral de rayos X de galaxias CA 0340 -538.

Cúmulos de fuentes de rayos X tienen una apreciable dimensión, siendo su diámetro de uno o dos millones de años luz. Se presume que la radiación de rayos X en estas fuentes no es más que la radiación termal de un tenue, muy caliente gas (con una temperatura de cien millones de grados) que llena las regiones interiores de los cúmulos. Hasta el momento aun no se puede responder a la pregunta de cual sería el origen de aquel gas.

Hasta la fecha, se han podido detectar sólo una o dos docenas de cúmulos de fuentes de rayos X. Es importante identificar estas fuentes a fin de estudiar en detalle los cúmulos ópticos.

El cúmulo CA 0340 -538 es un cúmulo casi esférico que tiene muchos cientos de galaxias. Para varias galaxias se han determinado las velocidades radiales, y se encuentra en progreso un estudio fotométrico. De las placas tomadas con el telescopio Schmidt en La Silla se está realizando también un estudio de la morfología y distribución de los varios tipos de galaxias en todo el cúmulo. Toda esta información, si se combina con los datos de rayos X, ayudará a explicar el origen del gas intercúmulo y su mecanismo de calentamiento.

Apolos y Troyanos

El título de esta nota no debe confundir a los lectores. No pretendemos discutir antiguos dioses y guerreros griegos, sino más bien resumir algunas nuevas informaciones pertenecientes a estas dos «familias» de planetas menores recientemente obtenidas a través de observaciones con los telescopios de la ESO. Ellos representan casos extremos en el mundo de los asteroides: los planetas de tipo Apolo son aquellos que más se acercan a la tierra, los Troyanos son los más distantes de todos los conocidos planetas menores.

1976 WA

Hasta la fecha se conocen comparativamente pocos asteroides de tipo Apolo. Recientemente, el interés en estos raros objetos ha aumentado considerablemente luego del descubrimiento de no menos de cuatro nuevos Apolos dentro de sólo once meses. A fines de 1975 fueron descubiertos dos en el Observatorio Palomar (1976 AA y 1976 YA), el tercero en octubre de 1976, igualmente en Palomar (1976 UA), y el cuarto, 1976 WA, fue el primero encontrado con el telescopio Schmidt de ESO, para el cual se ha establecido igualmente una órbita fiable.

1976 WA fue descubierto por H.-E. Schuster en una placa tomada para el Mapa (B) de ESO el día 19 de noviembre de 1976. El tamaño de 1976 WA se estima en 1–1.5 kilómetros. Su órbita es extremadamente alargada y se mueve entre 124 y 598 millones de kilómetros del sol, es decir, pasando bastante detrás de la órbita de Marte y casi tocando la de Venus.

1976 UQ y 1976 UW

Algunas semanas antes del descubrimiento de 1976 WA, se realizó un pequeño programa de observación con el telescopio de Schmidt de ESO con el fin de buscar sistemáticamente nuevos asteroides de tipo Apolo. Dr. R. M. West, asistido por Guido Pizarro, obtuvo seis placas durante un período de diez noches. Se encontraron 27 planetas menores en las placas, 25 de los cuales eran nuevos descubrimientos!

Entre los 25 objetos no habían nuevos asteroides de tipo Apolo. Sin embargo, sorpresivamente, dos de los nuevos asteroides resultaron ser nuevos Troyanos con una distancia de casi 750 millones de kilómetros de la tierra. Una extraña paradoja: se busca lo cercano y se encuentra lo distante.