- Catalog of Small Extended Sources.

Several other, more primitive products, various IRAS databases, including the LRS database, and large-scale maps (Spline I, Spline II) will remain at the designated IRAS Centers.

These Centers are:

Netherlands: Leiden, Groningen, and Amsterdam Astronomical Institutes;

UK: Rutherford Appleton Labs, Chilton;

USA: SDAS Center, now at JPL, Pasadena, to be moved to Caltech summer 1985.

All three Dutch data centers possess the officially released products as well as additional handling software. There is some specialization, however:

Amsterdam

Pannekoek Institute: All official products plus Astronomical Catalogs for cross-referencing with IRAS PS catalog.

Groningen

Ruimteonderzoek: All official products plus CPC Spline I, II Database, Survey Database (PASS), Colour Display (AO Deep Sky Grids).

Leiden

Sterrewacht: All official products plus LRS Database. (Spline I, II) Survey Database (CCDD), Plate Scanning Device plus software, Colour Display, AO Deep Sky Grids.

All *officially* released products will also reside at the Stellar Data Centre, Strasbourg.

European astronomers wishing to make use of IRAS data are kindly requested to take note of the following:

- Copies of IRAS official products as mentioned above should be requested from the Stellar Data Center, Centre de Données Stellaires, Observatoire de Strasbourg, 11, Rue de l'Université, F-67000 Strasbourg. Dutch centers will not, as a rule, supply copies; requests will be passed on to Strasbourg.
- Under certain conditions, European astronomers will have access to databases and software (not officially released) at one ot the Dutch data centers.
  Due to manpower restrictions, only limited service is available, so that prospective users will generally be required to come to the Netherlands in person.
- Small programs will entail a stay in the Netherlands varying from a minimum of two days to one or two weeks. Manuals and advising personnel are available for this type of program.
- Larger programs, making extensive use of IRAS products, databases and software, will require a longer stay and more extensive interaction with Dutch staff, possibly in the form of a full collaboration.
- Prospective European users of the Dutch facilities are in all cases requested to contact:

Chairman Dutch IRAS Steering Group
Dr. H. J. Habing
Sterrewacht Leiden
Wassenaarseweg 78
2300 RA Leiden

Nova-like Objects and Dwarf Novae During Outburst – A Comparative Study

W. F. Wargau, University of South Africa

General Remarks on Cataclysmic Variables

The Model

Novae, recurrent novae, dwarf novae and nova-like objects form subgroups of a class of objects well known as cataclysmic variables. Detailed photometric and spectroscopic work during the past thirty years has shown that all of them are interacting double stars. The primary component represents a massive white dwarf—the mass average lies at about one solar mass, and much of the observed dispersion is due to uncertainties in the reduction procedures—in contrast with field white dwarfs which possess an average mass at about 0.65 solar masses (Weidemann, 1968). The secondary component comprises a late-type main-sequence dwarf with spectral type K to M which fills its critical Roche volume, and spilling hydrogen-rich material via the Lagrangian point L1 to the highly evolved primary. Due to conservation of angular momentum the mass stream does not immediately impact the primary but leads to the formation of a quasi-stable accretion disk. At the impact zone of transferred material and particles in the outer disk region, an area of shocked gas—the so-called hot spot—is produced. By exchange of angular momentum, disk material spirals slowly inward, and is finally accreted onto the primary component. In fact, it is this interplay of mass transfer and accretion processes which is responsible for most of the peculiar behaviour observed in this class of objects.

The Outburst Activity

The principal difference between cataclysmic variables is linked with their outburst activity. Novae reveal less frequent outbursts with a quiescent phase of about 10^4 to 10^5 years between explosions, while recurrent novae erupt on the average between 10 and a few hundred years. The outburst amplitude is 7^m to 14^m, and the mean energy radiated per single eruption amounts to $\lesssim 10^{45}$ ergs. It is now well established that the nova explosions result from unstable thermonuclear burning of hydrogen-rich material, accreted and accumulated onto the surface of the otherwise hydrogen-exhausted white dwarf. The dwarf nova eruptions occur more frequently in intervals between 10 days and several years, their amplitudes range between 2^m to 6^m and the total energy released per outburst is of the order of 10^{38} to 10^{39} ergs. Due to recent theoretical models (Papaloizou et al., 1983) recurrent instabilities in the accretion disk itself—caused by different viscosity values—are responsible for the explosions. At low density the viscosity is low, and the material is stored in a ring. As soon as the density in this ring reaches a critical value, the viscosity increases rapidly and the ring expands into a disk with a great portion of its mass accreting onto the white dwarf. This conversion of gravitational potential energy of the ring into radiation causes the observed dwarf nova outburst. According to their outburst behaviour, the dwarf novae are subdivided into U Gem, Z Cam and SU UMa-type stars. U Gem-type stars exhibit typical dwarf nova eruptions: the rise to maximum brightness takes a shorter time than the recovery from maximum to quiescence. On the average an eruption lasts for several days. Z Cam-type stars are characterized by a brightness "standstill": after a regular outburst it sometimes happens that the brightness remains about one magnitude below peak brightness for an indefinite period of time (it can last hours to even years). SU UMa-type stars undergo, besides regular outbursts, additional superoutbursts which show a larger outburst amplitude (up to several magnitudes), and

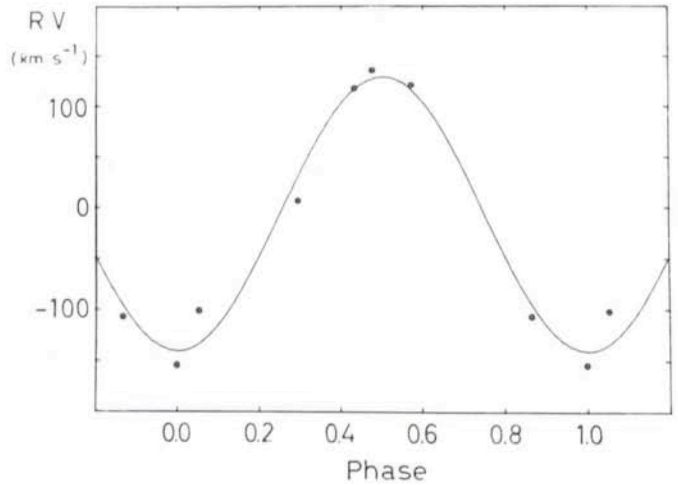

Fig. 1: *Radial velocity curve of CPD-48°1577. The orbital phase corresponds to the ephemeris JD 2445334.552 + 0.187 E day. For further explanations see text.*

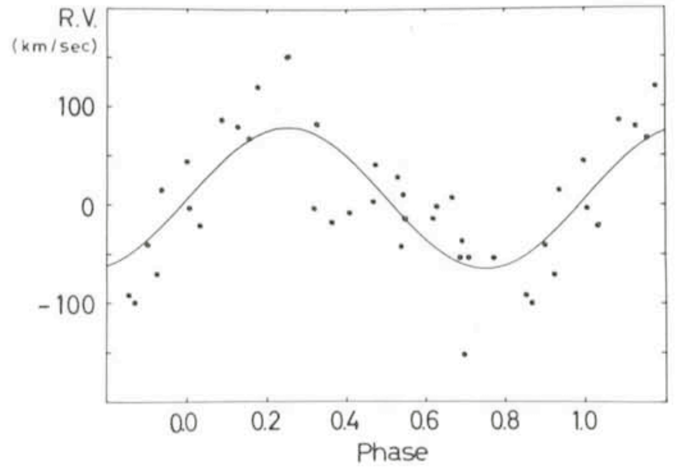

Fig. 2: *Radial velocity curve of HL CMa. The orbital phase corresponds to the ephemeris JD 2445329.560 + 0.2145 E day. For further explanations see text.*

whose durations are 3 to 4 times longer than that of a normal eruption. The nova-like variables show no spectacular explosion but their photometric and spectroscopic activities are closely related to cataclysmic systems.

Dwarf Novae—Nova-like Objects

Already in 1974, it has been suggested by B. Warner and W. G. van Citters that some nova-like variables, e.g., TT Ari, UX UMa, BD-7°3007, CD-42°14462, Feige 24 and VY Scl, could be Z Cam-type variables permanently stuck in a standstill phase. The authors concluded this from the similarity between dwarf nova spectra taken during outburst and nova-like spectra. Indeed, successful UV spectroscopy of TT Arietis with the IUE satellite during July 1979 and January 1981 has led to a reclassification as a Z Cam-type variable (Krautter et al., 1981; Wargau et al., 1982). In November 1980 the system showed a sudden drop from its mean brightness level of 11^{m} to $14\overset{m}{.}5$. The following month, December 1980, TT Ari rebrightened again, and returned to an intermediate brightness level of $11\overset{m}{.}8$ in January 1981. However, inspection of photographic material back to 1905 show no indication of a regular outburst. Additionally, the time to reach the intermediate maximum brightness took longer than usual. During 1981 and 1982 the brightness faded down to below 16^{m}, where the system has remaind up to now. Possibly, this indicates dramatic changes in the transfer and accretion processes which undoubtedly influence the evolution of TT Arietis. Certainly, more photometric and spectroscopic work has to be done on this peculiar system before a final classification can be made.

The Observation Programme

During the past years a long-term observing project of cataclysmic variables—with emphasis on dwarf novae and nova-like objects—has been established at ESO. Amongst the programme stars in particular two systems turned out to be most exciting: the nova-like variable CPD-48°1577 and the peculiar dwarf nova HL CMa.

CPD-48°1577—also catalogued as CD-48°3636, SS 1024 and KS 155—has been discovered recently as a cataclysmic variable by R. F. Garrison et al. (1982). The authors carried out a MK spectral classification survey of southern OB stars, and discovered some unusual characteristics in this system: the UBV colours are not typical of an OB star, continuous brightness fluctuations—so-called "flickering" —of the order of $0\overset{m}{.}1$ occur on a time scale of minutes, and the hydrogen and helium I and II absorption lines appear extremely weak and broad. Spectroscopic observations in the ultraviolet with the IUE satellite by H. Böhnhardt et al. (1982) revealed CPD-48°1577 as a nova-like object or a dwarf nova at outburst phase. Due to its remarkable brightness (in respect with cataclysmic variables) of $9\overset{m}{.}4$, CPD-48°1577 is one of the brightest cataclysmic systems.

HL CMa represents the optical counterpart of the variable, hard X-ray source 1E0643.0-1648 (Chlebowski et al., 1981). Its long-term optical variability as well as its photometric behaviour (flickering activity) makes this system a typical member of the dwarf nova class. HL CMa exhibits a quite short mean outburst cycle of 15 days.

The corresponding spectroscopic observations were carried out in December/January 1982/1983 with the ESO 1.5 m telescope equipped with the Boller & Chivens Cassegrain spectrograph and an Image Dissector Scanner (Wargau et al., 1983a, 1983b). The spectra covering a wavelength range from 4080 Å to 5260 Å have a dispersion of 59 Å/mm. Additional infrared photometry in the filters J (1.25 μm), H (1.65 μm), K (2.2 μm) and L (3.4 μm) with the ESO 1 m telescope using an InSb photometer was obtained in January/February 1983 (Wargau et al., 1984). The integration time of a single filter measurement was 20 seconds, and in the reduction procedure a set of JHKL data were connected together.

The Comparative Study

The Orbital Periods

For CPD-48°1577 we obtained 5 spectra continuously over a time interval of several hours. In the case of HL CMa, 31 spectra could be taken in three consecutive nights. The orbital periods have been derived by the radial velocity measurements of the hydrogen emission lines. The corresponding radial velocity curves of CPD-48°1577 and HL CMa are displayed in Figs. 1 and 2, respectively. The dots represent the velocities of the hydrogen lines; the solid curve is a least squares sine-fit to the data. While for HL CMa the orbital period is quite well determined, the data for CPD-48°1577 are rather poor. Therefore, the latter period can only be considered as preliminary so far. The derived orbital periods are $4^{h}29^{m}$ and $5^{h}09^{m}$ for CPD-48°1577 and HL CMa, respectively.

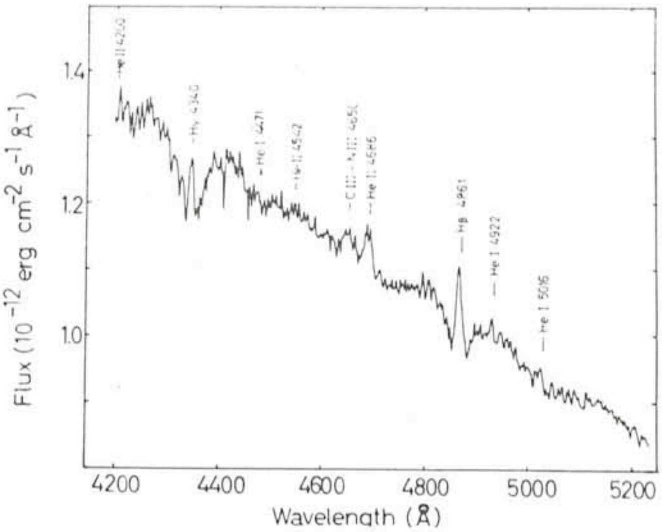

Fig. 3: *Spectrum of CPD-48°1577. The spectrum represents a mean of five individual IDS spectra taken on December 30, 1982. The ordinate is given in absolute flux units which were obtained by using absolutely calibrated ESO standard stars. A correction for interstellar extinction has not been applied.*

Our orbital period for HL CMa is close to the longer period suggested previously by Hutchings et al. (1981).

The orbital periods of cataclysmic variables are generally in the range from 80 minutes to 10 hours. By an inspection of all the available orbital periods one finds a clear gap in the 2 to 3 hour range. All objects with periods $P \gtrsim 3$ hours are either novae, nova-like systems, U Gem or Z Cam subtypes; those with periods $P \lesssim 2$ hours are all SU UMa subtypes. The AM Her stars (a subtype of nova-like variables) are the only systems that bridge the gap. Our derived orbital periods fit quite well into this picture.

The Spectral Features and Continuum Distributions

For other reasons, the collected spectra seemed to be rather exciting: in our first observing night the dwarf nova HL CMa was at the final ascent to peak brightness, remained in its outburst stage in the subsequent nights, and started to decline during the last observing night. The prospects are a direct comparison of an erupting dwarf nova and nova-like system. Figs. 3 and 4 show the spectra of CPD-48°1577 and HL CMa, respectively. Apart from the fact that the flux level in the nova-like system is a factor of 10 higher, the spectra reveal striking similarities: a relatively strong blue continuum is superimposed by broad hydrogen (Balmer) absorption troughs which are partly filled in by moderately strong emission components. Helium II (4686 Å), Helium I (4922 Å and 5016 Å) and Carbon III–Nitrogen III (4650 Å) lines are present in emission. Even the structure of the emission line profiles bear a strong resemblance: up to four different emission peaks can be distinguished. Figs. 5 and 6 show tracings of the hydrogen profiles arranged in respect with the orbital phase for CPD-48°1577 and HL CMa, respectively. In particular, no systematic variations with the orbital revolution can be inferred. In fact, those profiles reflect a complex velocity structure of the emitting region which can be attributed to the velocity structure in the accretion disk itself.

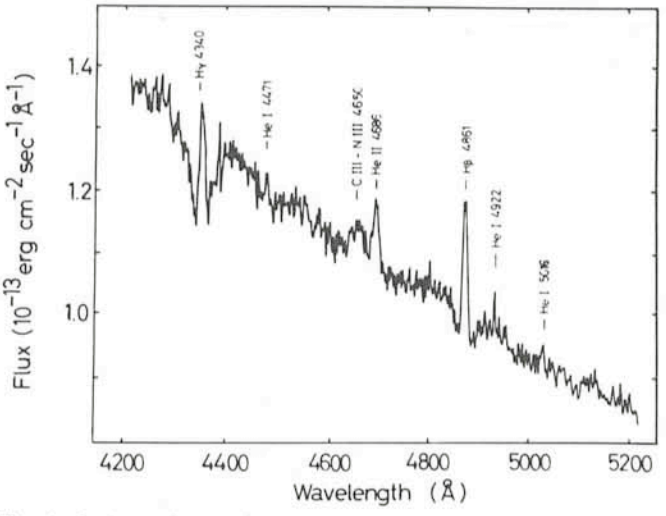

Fig. 4: *Outburst Spectrum of HL CMa. The spectrum represents a mean of eight individual IDS spectra taken on December 26, 1982. The ordinate is given in absolute flux units which were obtained by using absolutely calibrated ESO standard stars. A correction for interstellar extinction has not been applied.*

According to the cataclysmic variable model the wings of the absorption troughs should be generated by fast rotating particles in the innermost regions of the accretion disk in the vicinity of the white dwarf, while the emission lines reflect the motion of the particles in the outer disk regions. We investigated the involved velocities and found that the velocities reflected by the wings are about 2,200 km/sec and 4,000 km/sec, and the velocities derived at the half width at half maximum of the emissions are about 400 km/sec and 550 km/sec for CPD-48°1577 and HL CMa, respectively. In each case the velocities are corrected for the orbital inclination of the corresponding system. Also, the widths of the Helium II (4686 Å) line reveal quite similar results for both systems: the attributed velocities are some 30 % larger than those of the hydrogen lines, indicating that they originate in hotter inner areas of the accretion disk.

The Infrared Observations

During our observing period, the infrared colours of CPD-48°1577 remained essentially constant. Furthermore, we checked a possible dependence of the infrared brightness on the orbital phase but were not able to find any dips or humps in the light curves. Actually the data show a large amount of scattering which could well overshade small occultation or eclipse effects. The mean infrared colours are similar to those of other nova-like systems. On the other side the corresponding colours of dwarf novae at quiescence are on the average considerably redder. This might be due to different infrared contributions by the accretion disks and/or the late-type companion in dwarf novae and nova-like systems.

Conclusion

From our spectroscopic results it is quite obvious that CPD-48°1577 and HL CMa (at outburst stage) are closely related systems—in respect to the line features, the line profile structure and the continuum shape. So we might well conclude that the nova-like system CPD-48°1577 is a further candidate which is stuck in a permanent outburst stage—a dwarf nova of Z Cam subtype.

However, before a final decision can be drawn, a few "irregularities" have to be taken into consideration. First of all, the long-term variability—as derived from Bamberg sky-survey plates recorded between December 1963 and January 1973—shows no evidence for a quiescence stage or a pre-

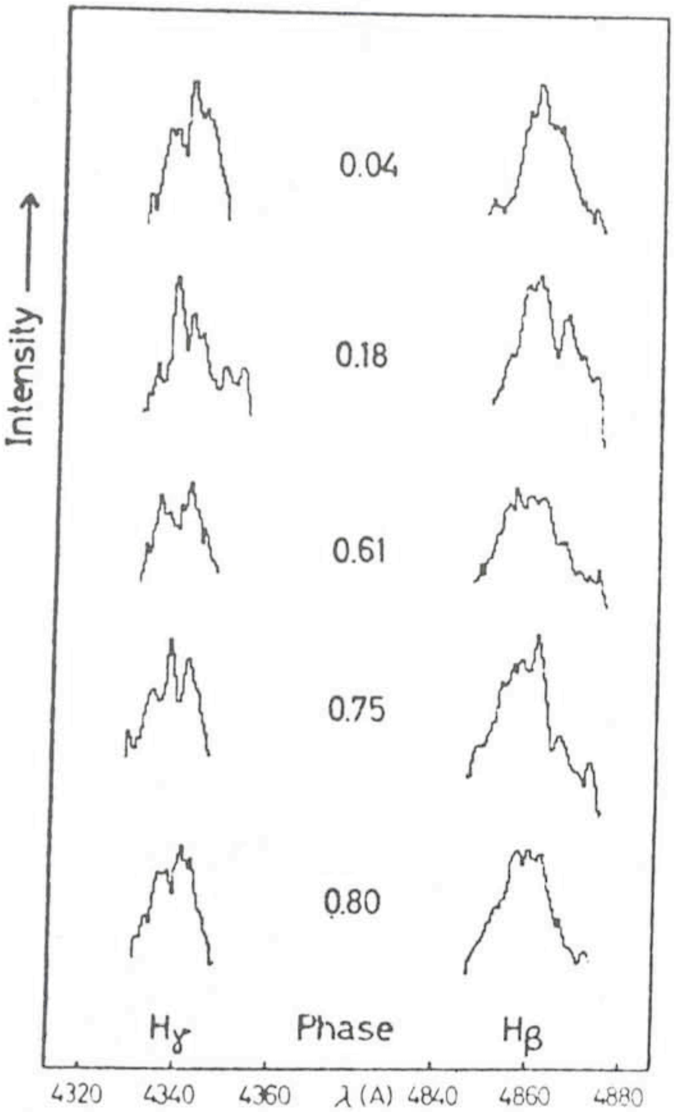

Fig. 5: *Emission line profiles (Hγ and Hβ) of CPD-48°1577. The profile tracings are arranged according to the orbital phase. The ordinate is given in relative intensities.*

ceding eruption. It may be that the time interval of the sky-survey plates is too short to allow for a definite statement. Also some spectral characteristics of HL CMa, as well as CPD-48°1577, appear more typical for ex-novae, e.g. the presence of the carbon III – nitrogen III (4650 Å) blend. Did CPD-48°1577 undergo an unrecorded classical nova outburst? In that case CPD-48°1577 would be one of the brightest known ex-novae. HL CMa at quiescence shows some evidence for a magnetic field of intermediate strength which, indeed, is not a

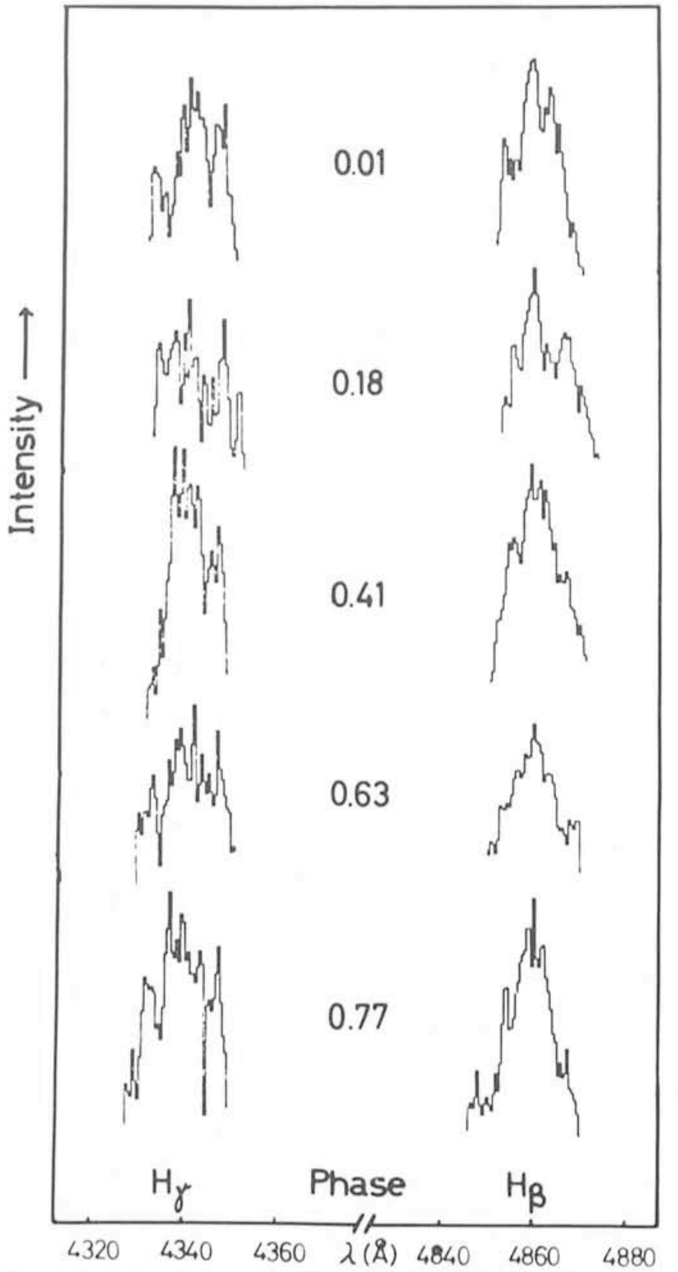

Fig. 6: *Emission line profiles (Hγ and Hβ) of HL CMa. The profile tracings are arranged according to the orbital phase. The ordinate is given in relative intensities.*

common dwarf nova feature; although its photometric appearance is typical for this group of stars.

In view of its brightness of $9\overset{m}{.}4$, CPD-48°1577 could become one of the most observed cataclysmic variables in the future. Professional astronomers, as well as amateurs, might find this system prolific for extended astronomical studies.

The Proceedings of the ESO Workshop on

The Virgo Cluster of Galaxies

which took place in Garching from 4 to 7 September 1984, have meanwhile been published. The price for the 477-page volume is DM 50.– (US$ 18.–) and has to be prepaid.

If you wish to receive the Proceedings, please send your cheque to ESO, Financial Services, Karl-Schwarzschild-Str. 2, D-8046 Garching b. München, or transfer the amount to the ESO bank account No. 2102002 with Commerzbank München.

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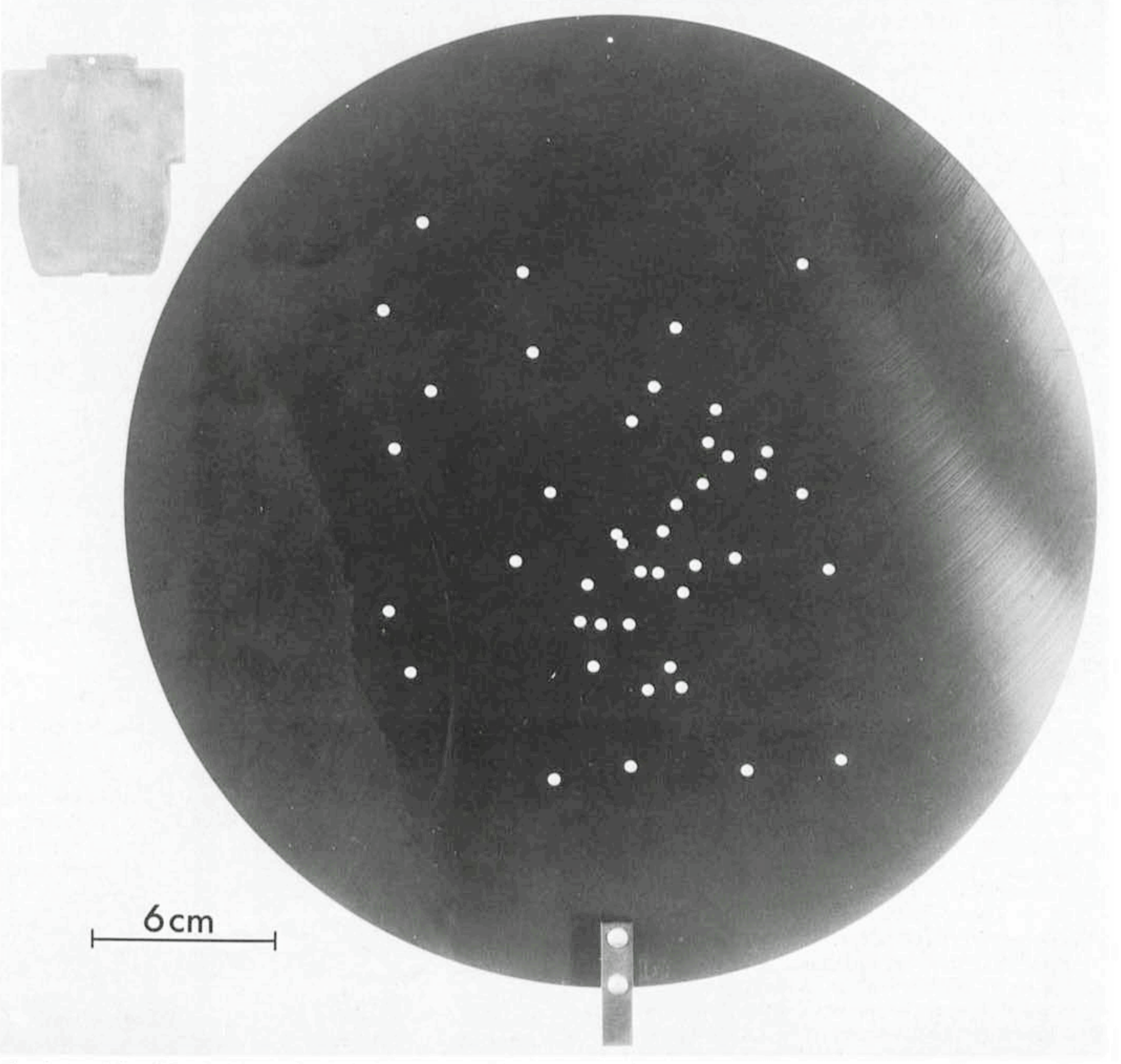
Two Multi-Object Spectroscopic Options at the ESO 3.6 m Telescope

In March, two instruments to obtain the spectra of several objects in a field in a single exposure were successfully tested at La Silla.

An improved version of OPTOPUS (see the *Messenger* No. 33 for a description of the prototype) has been used at the Cassegrain focus of the 3.6 m telescope. With this instrument, the light of up to 54 objects in a field of 33′ diameter is guided by fibers to the slit of a modified B&C spectrograph. A CCD is used as a detector. In the three test nights, the instrument operated smoothly on 8 fields and more than 300 objects were successfully observed.

OPTOPUS will be offered to the users as of October 1, 1985.



The giant and the midget: both attractive in their own way. In this picture, taken in the ESO Photolab, an OPTOPUS plate with holes to fit the optical fibers is shown close to a much smaller plate to be mounted on the EFOSC aperture wheel. Both combinations sample targets for multi-object spectroscopy at the Cassegrain focus of the 3.6 m telescope.