measurements are under way, and the first results, though as yet inconclusive, look promising. It therefore was decided that the VLT proposal should present Paranal as the more likely option, even though a definitive choice need not be made before three years from now.

Paranal is a remote place in one of the world's driest deserts. While a good gravel road passes close by, there is no village or anything within many kilometers. So the complete infrastructure will have to be built there by ESO. A development of Paranal along the lines of La Silla would be costly and time-consuming, but fortunately also not necessary.

Remote control is being used at La Silla on an experimental basis. For the VLT it will be the principal mode of use. Remote diagnostics and trouble shooting will undoubtedly follow. With such technologies, it would seem that the Paranal site may be run with a comparatively small number of highly qualified staff. Another factor which reinforces this conclusion is that the VLT – like the NTT – will be operated with very few instrument exchanges.

Suppose the VLT were placed at Paranal, what about the other ESO telescopes? With its 16-m equivalent diameter, the VLT would represent nearly 85% of the total photon collecting area of the ESO telescopes. It would seem hard to imagine that ESO would continue to operate another site at high cost for the remaining 15%. In the long run, there appears to be only one solution: if the VLT were to be placed at Paranal, all of ESO's telescopes would have to be operated there. This might involve the moving of some of the La Silla telescopes. Moving the 2.2 m, CAT, 1.5 m DK and SEST would not present major problems; the 3.6 m is too cumbersome to move, except perhaps as a "zenith telescope" for cosmological studies. What really would be useful to move more than a decade from now remains to be seen at that time.


Professor H. van der Laan, who will become Director General from January 1, 1988.

The NTT poses a particular problem. Within a year, it will be ready for installation in Chile. If Paranal were ultimately to be chosen as the VLT site, would it not be more rational to place it there? While the advantages of learning to operate a modern telescope on Paranal before the arrival of the VLT would be important, there are serious problems with regard to the time scale; these are currently being analyzed. Should it appear that the Paranal location would cause undue delays, the NTT would still be placed at La Silla.

Astronomers have been accustomed to look at telescopes as instruments of almost eternal use. This was perhaps reasonable at a time in which maintenance needs were small and instrumentation relatively simple. At present, however, the annual costs of operating and instrumenting a modern telescope at a remote site and processing the resulting data far exceed the capital investment prorated over one or two decades. It follows that the acquisition of new telescopes must automatically be accompanied by the closing of existing ones.

The VLT represents ESO's long range future. Without it the Organization could not survive very long. However, for more than a decade, La Silla will continue to provide the data essential for the scientific work of a large community. It is clear, therefore, that even if Paranal were to be developed, everything will have to be done to guarantee the continuation of the functioning of La Silla at its present high level of quality.

L. WOLTJER
Director General

The Swedish-ESO Submillimetre Telescope

R. S. BOOTH, Onsala Space Observatory, Chalmers Tekniska Högskola, Göteborg, Sweden
M. J. DE JONGE, Institut de Radioastronomie Millimétrique, Grenoble, France
P. A. SHAVER, European Southern Observatory

Introduction

Dramatic changes have taken place during the past two years at the southern end of the telescope ridge on La Silla and now, where once stood a meteorological station, stands a 15-m submillimetre telescope. The telescope, designed by IRAM engineers, has been built on behalf of the Swedish Natural Science Research Council (NFR) and ESO. It will be operated jointly by ESO and NFR (through the Onsala Space Observatory).

The **S**wedish-**E**SO **S**ubmillimetre **T**elescope, acronym SEST, while not actually breaking new ground at ESO, since some groups have already used the 3.6-m and other telescopes at submillimetre wavelengths, represents a significant breakthrough as a dedicated sensitive millimetre-submillimetre instrument. It is the only telescope of its kind in the southern hemisphere and among the first such instruments in the world.

SEST will extend the observational part of the radio spectrum towards the infrared and will enable European astronomers to probe the molecular clouds of the southern Milky Way and other nearby galaxies, providing information on stellar evolution and galactic dynamics. It will enable them to investigate the radio continuum properties of the stars, H II regions and interstellar dust in this new wavelength region, and provide valuable new data on quasars and radio galaxies in the submillimetre wavelength regime. SEST may also become an extension of the existing VLBI arrays for the study of the submilliarcsecond properties of low declination radio sources.

Background

The idea of building an IRAM design telescope on La Silla was first conceived by the astronomers of IRAM and Onsala Space Observatory, and enthusiastically supported by ESO. The outcome of the subsequent negotiations between the parties and their funding agencies was an agreement between the Swedish Natural Sciences Research Council and ESO to install and operate the 15-m telescope on La Silla and share the expense and the observing time over a 15-year period. IRAM agreed to build the telescope under contract with ESO. As part of the agreement, Onsala Space Observatory has the technical responsibility for the first receivers and the overall project.

The formal agreements were signed at a small ceremony at Onsala Space Observatory on June 26, 1984. Under a separate Nordic agreement related to the Nordic Optical Telescope (NOT), Finnish astronomers will benefit from 10% of the Swedish observing time.

The Importance of La Silla

La Silla is an important site for SEST on two counts. The first is its southern location, making the telescope unique as the only major telescope in the southern hemisphere to operate below 3 mm wavelength. The second is the low atmospheric attenuation above this dry mountain site. Figure 2 shows the relative transmission of the atmosphere as a function of frequency for 1 and 4 mm of precipitable water. The atmospheric water vapour content above La Silla is below 4 mm for nearly one hundred per cent of the time during the winter months, with some days below 1 mm. These are very good observing conditions, and early experience with the telescope shows the enormous improvement over a typical sea-level site.

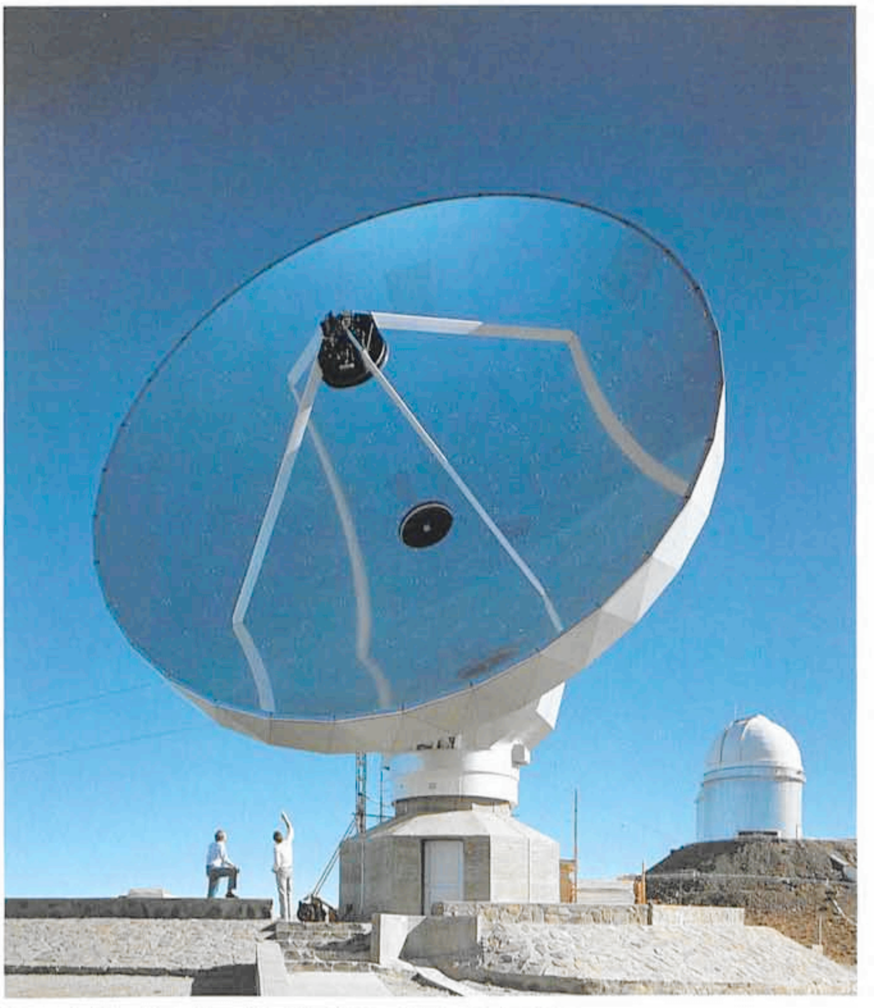

Figure 1: *The 15-m Swedish-ESO Submillimetre Telescope.*

The Telescope

The general specifications for SEST are given in Table 1. The telescope is designed to achieve a reflector profile accuracy of 50 microns r.m.s., giving good (coherent) performance down to wavelengths ≤ 0.8 mm (375 GHz). (The Ruze criterion on performance of radio telescopes gives 50% efficiency at a wavelength of 16 × r.m.s. error).

The antenna (described by Jean Delannoy at the Aspenäs ESO-IRAM-Onsala Workshop on (sub)millimetre astronomy) is identical to three others being built by IRAM on the Plateau de Bure, France, as movable elements of an interferometer. From the outset, therefore, an essential design requirement was the capability to operate without a radome or other enclosure normally associated with telescopes of this precision. This is only achieved through new technology. The new concept behind these antennae is the extensive use of carbon fibre, in both the backing structure and the reflector. The material is light-weight and therefore gravitational distortion is small, and it has a low temperature coefficient, thereby minimizing the effects of temperature gradients on the surface profile. Finally, the telescope is designed using von Hoerner's homology principle, which means that it is not an extremely stiff structure and is allowed to distort as a function of elevation angle. The flexure is, however, constrained such that the reflector always retains a parabolic form and, by the simple expedient of moving the subreflector an appropriate predetermined amount, the focus is maintained and with it the efficiency of the paraboloid. The telescope can operate within the specifications in winds up to 14 ms^{-1} and under temperature gradients of up to 10°C across the surface.

The SEST reflector consists of 176 panels, each mounted at 5 points, all of which have servo-controlled motors for adjustment. The telescope has been surveyed by A. Greve of IRAM using a direct (theodolite and measuring tape) method in the zenith pointing position. By successive adjustment of the panels a parabolic profile has been achieved with an r.m.s. accuracy of 80 microns. Further such adjustment, it is hoped, will result in an r.m.s. of better than 70 microns. Final trimming of the surface will be attempted either using the technique of holography on a satellite transmission

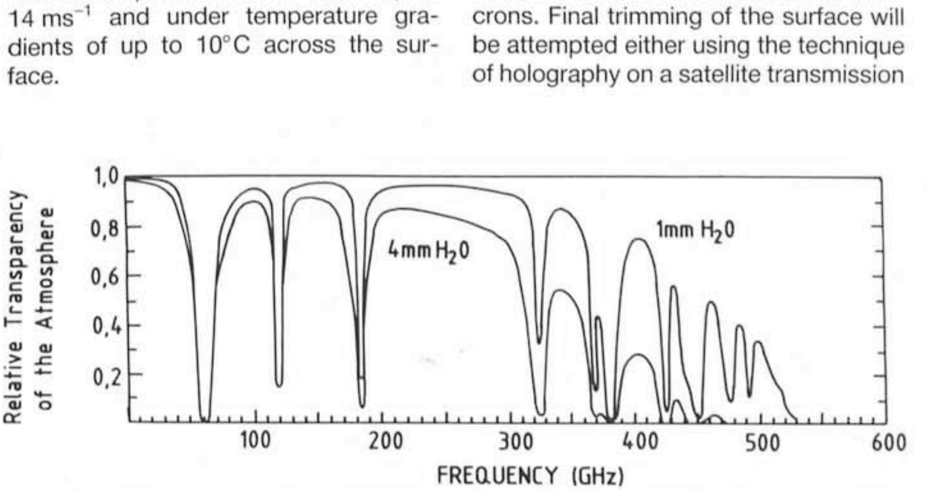

Figure 2: *Transmission through the atmosphere with 1 and 4 mm of atmospheric water vapour.*

TABLE 1. *SEST Specification*

Main reflector	Axisymmetric paraboloid
Diameter	15 m
f/D	0.325
Tolerance	50 microns r.m.s.
Focus for receivers	Cassegrain
Subreflector diameter	1.5 m
Magnification	15.7
Half power beam width (12 db edge tapes)	50″ at λ 3 mm 17″ at λ 1 mm
Pointing accuracy	2 arcseconds
Environmental constraints	
Max. wind for operation	14 m s^{-1}
Max. wind for survival	56 m s^{-1}
Icing load	10 cm
(De-icing heaters are provided)	

or by optical methods. The latter technique may be possible because individual panels have a highly reflective surface with a precision of ~16 microns on average. The optical performance of the SEST reflector was inadvertently tested during construction when, due to an oversight, the reflector pointed within 10 degrees of the sun; the consequent concentration of power at the edge of the sub-reflector caused some damage to the sub-reflector and several panels, which has since been repaired. Because of the good optical performance of the panels it is hoped that SEST may be used as a "light bucket" at frequencies considerably in excess of 375 GHz.

Receivers

Under the NFR-ESO agreement, Onsala Space Observatory (Department of Radio and Space Science of Chalmers University of Technology) is responsible for the first receivers. All are dual polarization systems based on Schottky-diode mixer front-ends cooled to 15 K in closed cycle refrigerators. They are designed to be controlled and monitored by computer. A chopper wheel system is available for calibration and beam-switching. The front-ends feed cooled FET intermediate frequency amplifiers, centre frequency 4 GHz, although a 1.5 GHz I.F. is also available. A continuum back-end and two Acousto-Optic spectrometers (AOS), built by the University of Cologne, will be provided. The first AOS (bandwidth 100 MHz, resolution 50 kHz) is already in use, and a second (bandwidth 500 MHz, resolution 500 kHz) is being built.

The first receiver in operation on SEST tunes over the band 85–117 GHz and has an instantaneous bandwidth of 500 MHz. Its noise temperature is 250 K, single side-band (SSB). This is being used for telescope tests, pointing, etc., and will be the first available for observation. The second receiver system is still under construction. It is designed to cover the range 220–280 GHz (B/W 500 MHz) and the expected noise temperature is ~600 K (SSB). The SEST submillimetre receiver will also be built at Onsala, and will cover a band near 345 GHz. Finally, we are discussing the possibility of providing a submillimetre broad-band bolometer system for continuum observations and a VLBI back-end is also under consideration.

Control and Data Analysis

SEST and its associated instrumentation is controlled by two networked mini-computers: an HP A900 and an HP A600. The A900, the main computer, has 1.5 megabytes of primary memory and 120 megabytes of disk space. The

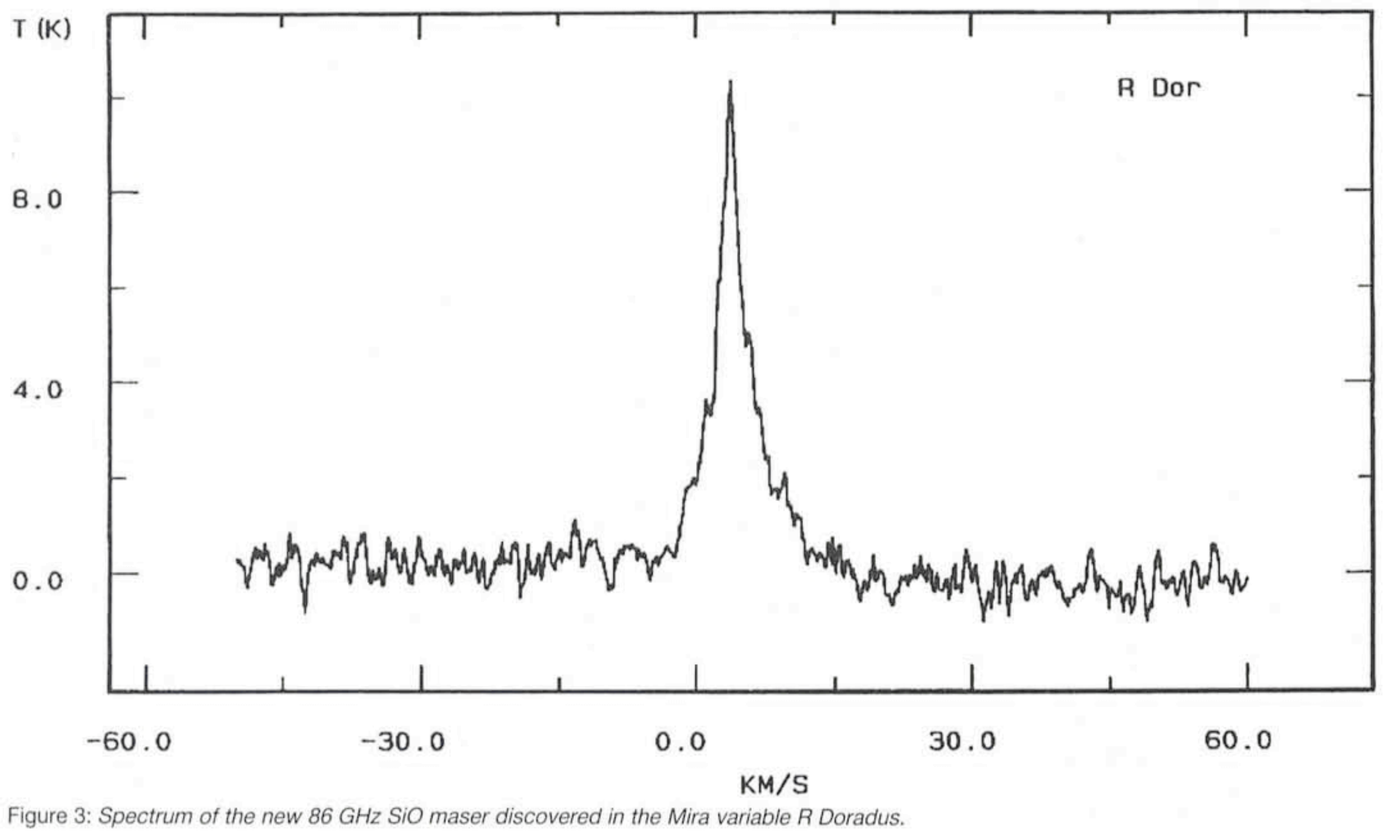

Figure 3: *Spectrum of the new 86 GHz SiO maser discovered in the Mira variable R Doradus.*

A600 is at present dedicated to the control of the AOS spectrometers. Instruments and sensors are interfaced to the computers via the industry standard bus systems GPIB and CAMAC.

Two popular on-line data reduction packages designed for radio astronomy are supported. These are POPS (People Oriented Parsing Service), a system developed in the USA, and Toolbox, a system developed in Germany. Users may also write their data to tape using the well-known FITS format for reduction by other popular off-line systems.

Proposals for SEST Observations

Routine observations using SEST will be allocated on a six-month basis, in accordance with the standard ESO observing schedule. They are expected to commence with period 41, starting 1 April 1988, for which the proposal deadline is 15 October 1987.

In the meantime, there will be opportunities for limited observations using the first receiver (85–117 GHz) and AOS (50 kHz resolution) starting in August or September, during the testing and calibration phase. These opportunities are necessarily restricted to astronomers with considerable experience in millimetre wave observations, who are willing to work with an evolving system and contribute to its development. Proposals for this period should be submitted as soon as possible to the Visiting Astronomers Office in Garching.

Operations

The operation of SEST on La Silla is in the hands of a team comprising:

Scientist in Charge:
Lars E. B. Johansson
Microwave Engineers:
Magne Hagstrom, Nick Whyborn;
Software Scientists:
David Murphy, Michael Olberg

This dedicated group has been heavily involved with receiver and software development for more than a year. Two further persons will soon be added to this team.

Following its completion under the supervision of Dietmar Plathner, the new telescope was handed over to the team at La Silla on March 13, 1987 and "first light" was obtained on March 24. Commissioning is now under way, and series of tests designed to determine the pointing and homology characteristics and the receiver performance, and to streamline the control system, are in progress. When these are complete, experienced millimetre astronomers will be invited to try out the system. SEST should become generally available in early 1988 after the 230 GHz receiver has been commissioned. Proposals will be accepted for the ESO October deadline. Sweden and ESO will handle their respective proposals through separate programme committees and time will be allocated to the two parties on a 50–50 basis.

Scientific Programme

The scientific programme for SEST depends, of course, on the interests of the user community. A full discussion of the potential programmes for the telescope took place during the Aspenäs workshop (ESO Conference and Workshop Proceedings No. 22, 1985). While the millimetre and submillimetre spectral region is usually considered the province of molecular line astronomy and cosmochemistry, we saw a great deal of interest in continuum studies both of interstellar dust, active galactic nuclei and quasars, and the cosmic background radiation since the Sunyaev-Zeldovich decrement changes sign between 2 mm and 800 microns wavelength.

In the field of molecular spectroscopy the southern sky has great potential because the southern Milky Way contains a plethora of important dark clouds and H II regions, many with unusual features. Probably one of the most important although poorly understood discoveries of molecular line astronomy is the fact that so many protostars in the Galaxy go through the stage of bipolar outflow. The southern sky is rich in optical signposts of bipolar flows, such as Herbig-Haro objects, and this points to a feast of new observational data. Their observations in the new wavelength range and with the higher resolution provided by SEST should help us understand this unexpected phenomenon.

At the other end of the evolutionary scale, the study of mass loss from evolved stars, Mira variables and red giants is an exciting prospect, particularly in view of the host of IRAS objects now waiting to be observed at millimetre wavelengths. One of the first observations with SEST provided the detection of a new 86 GHz SiO maser in a Mira variable, R Doradus (Figure 3).

In the past few years we have seen much interesting work on the carbon monoxide distribution and molecular cloud dynamics in nearby galaxies. Again IRAS has been an inspiration and we now find that extragalactic CO is detectable in galaxies with recessional velocities greater than 8,000 km s^{-1}. The southern sky is rich in active galaxies and their observation will enhance the statistical data base needed to relate star formation rates to molecular emission, IR and continuum radio fluxes.

Finally, solar system objects will not be neglected with SEST. In fact, it may be possible to observe comet Wilson already next month. Observations of planetary atmospheres and the continuum emission from planets and asteroids at submillimetre wavelengths will be of great interest.

We look forward to these exciting discoveries, which have been made possible by the dedicated efforts of the many people involved.

List of ESO Preprints

491. B. Barbanis: Irregular Periodic Orbits. *Celestial Mechanics.* March 1987.
492. L. Milano, M. Rigutti, G. Russo and A. Vittone: Some Observed Peculiarities of the Triple System V 701 Cen. *Astronomy and Astrophysics.* April 1987.
493. S. Cristiani: Observation of the H II Galaxy Giving Origin to the Z = 0.3930 Absorption System of the QSO 1209+107. *Astronomy and Astrophysics Letters.* March 1987.
494. L. Koch-Miramond and M. Aurière: X-Ray and UV Observations of Omega Centauri with EXOSAT. *Astronomy and Astrophysics.* March 1987.
495. S. Cristiani et al.: Radial Velocities of Galaxies in the Cluster Klemola 22 from Observations with Optopus, the ESO Multiple Object Spectroscopic Facility. *Astronomy and Astrophysics.* April 1987.
496. E. Giraud: Malmquist Bias in the Determination of the Distance to the Hercules Supercluster. *Astronomy and Astrophysics.* April 1987.
497. G. Garay: The Orion Radio Zoo: Pigs, Deers and Foxes. Invited talk given at the V. I.A.U. Regional Latin-American Meeting, Merido, Mexico (October 6–10, 1986). April 1987.
498. B. Binggeli, G.A. Tammann and A. Sandage: Studies of the Virgo Cluster. VI. Morphological and Kinematical Structure of the Virgo Cluster. *Astronomical Journal.* April 1987.
499. T. Le Bertre: Optical and Infrared Observations of Two Type-II OH/IR Sources. *Astronomy and Astrophysics.* April 1987.
500. Supernova 1987 A in the LMC. Astrometry (R. M. West et al.), Photometry (S. Cristiani et al.), Polarimetry (H. E.

Schwarz and R. Mundt), Infrared Observations (P. Bouchet et al.), Medium and High-resolution Spectroscopy (I. J. Danziger et al.; A. Vidal-Madjar et al.) *Astronomy and Astrophysics,* Letters. March 1987.

501. H. Dekker and B. Delabre: Simple, Wide-Band Atmospheric Dispersion Corrector. *Applied Optics.* May 1987.

502. L. Milano, G. Russo and A. Terzan: FS Lup: A Contact Binary in Poor Thermal Contact. *Astronomy and Astrophysics.* May 1987.

503. L. Binette, A. Robinson and T.J.-L. Courvoisier: The Ionizing Continua of Active Galactic Nuclei: Are Power Laws Really Necessary? *Astronomy and Astrophysics.* May 1987.

504. L. Binette, T.J.-L. Courvoisier and A. Robinson: Constraints on the Soft X-Ray Continuum of AGN Derived from Photoionization Models. *Astronomy and Astrophysics.* May 1987.

505. T.J.-L. Courvoisier and M. Camenzind: Magnetic Field and Synchronization in Mildly Relativistic Shocks. *Astronomy and Astrophysics.* May 1987.

High Speed Multicolour Photometry of the X-ray Burster MXB 1636-53

R. SCHOEMBS, M. PFEIFFER, R. HAEFNER, Universitäts-Sternwarte München
H. PEDERSEN, ESO

1. Introduction

X-ray burst sources are thought to be low-mass binary systems in which a mass-losing late-type main-sequence star transfers matter via an accretion disk onto a neutron star. The high potential energy of the material is converted to high kinetic energy, which subsequently thermalizes and escapes as X-rays. Depending on the temperature, the strength of the magnetic field and the accretion rate of the neutron star, a thermonuclear flash can occur on its surface from time to time. Within seconds a total energy of about 10^{39} erg is released. The resulting radiation is predominantly in the X-ray band. Burst intervals are mostly irregular and range from hours to days. There is no clear relation between the shape of the burst, the intervals and the continuously emitted X-ray level. Black-body fits to the energy distribution of the bursts yield temperatures up to 10^7 K and a radius of the emitting area of approximately 10 km thus supporting the neutron star model.

Optical bursts correlated with X-ray bursts have been observed for several sources. The shape of an optical burst is similar to that recorded in the X-ray range, whereas its energy content is a fraction of 10^{-4} only. Nevertheless, this is more than expected from an extrapolation of the X-ray spectrum. Usually the optical burst is delayed by a few seconds. This can be understood as a consequence of the longer light path from the X-ray source via the place of reprocessing to the observer, compared to the path on the direct way.

MXB 1636-53 (optical counterpart: V 801 Ara) is one of the best studied examples in both the X-ray domain and the optical region. Several coincident X-ray/optical bursts were recorded and

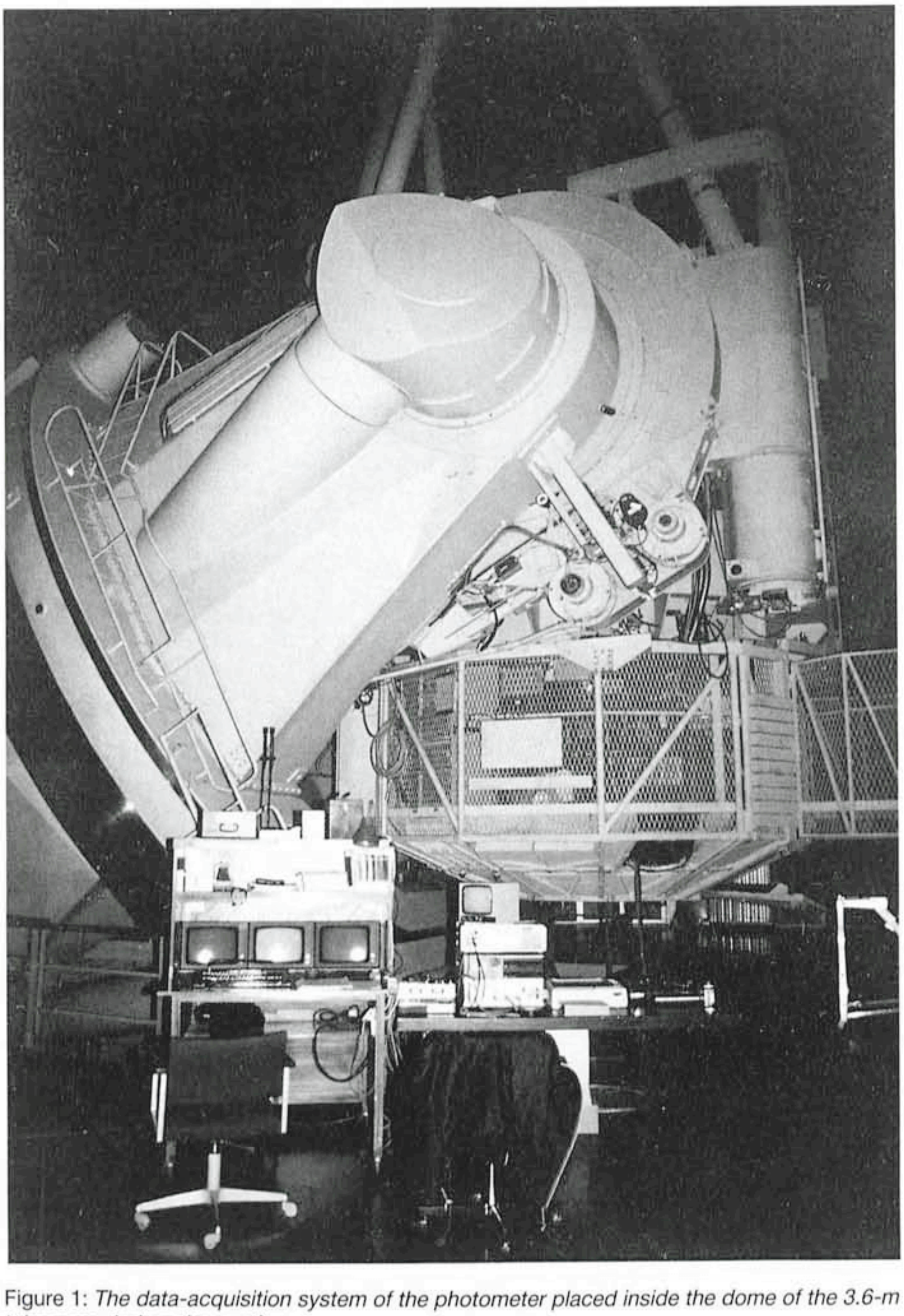

Figure 1: *The data-acquisition system of the photometer placed inside the dome of the 3.6-m telescope during observations.*