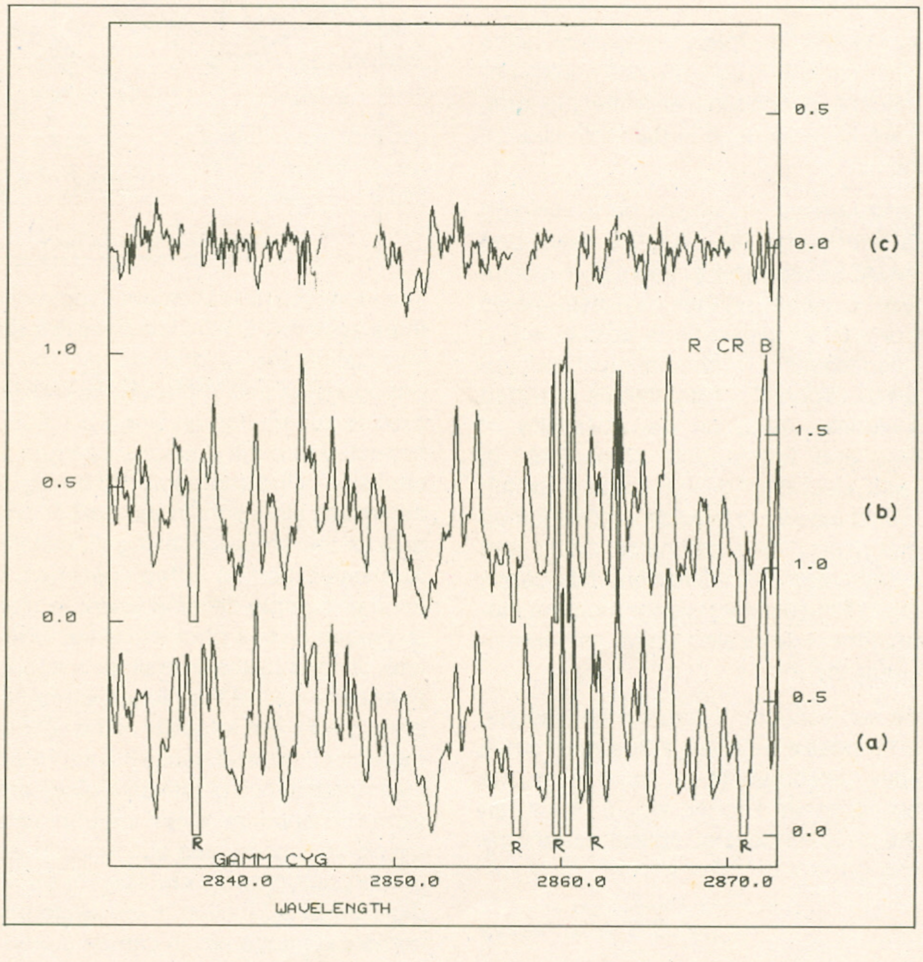
Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics

Volume 1 Number 4 October 1986



(a) The spectrum of γ Cyg (image LWR 8965) converted into continuum units. The regions where Raseau marks occur are indicated by 'R', and left as a gap in the difference spectrum (c). (b) Spectrum of R CrB (image LWR 8964). (c) The difference spectrum of R CrB and γ Cyg. Conspicuous feature is the emission peak and two absorption components in Mg I λ 2852. The scale for this frame is marked at the right.

from the director

National Facility for Optical Astronomy

The 2.3-m Vainu Bappu Telescope (VBT) is now being offered to the Indian astronomical community as a National Facility for Optical Astronomy. All proposals for observations will be referred to a national committee for telescope time allocation, and the allotment will be based primarily on the scientific merit and feasibility of the proposal, irrespective of the institution/university of its origin. The proposals may be made in the prescribed forms which will be available shortly.

Proposals for observation are invited also for the smaller telescopes including the 0.45-m Schmidt telescope. The smaller telescopes, particularly the Zeiss 1-m reflector, have been made available in the past to groups from other institutions, who have either used the instruments available at the telescope or brought their own instruments. Programmes involving collaboration with IIA have been preferred during allotment of telescope time. This policy will continue for telescopes other than the 2.3-m VBT.

Similarly, facilities for data reduction, such as the PDS micro-densitometer in IIA Bangalore, will also be available to astronomers all over the country.

As a part of the National Facility for Optical Astronomy, plans are afoot to form an instrumentation cell. The cell would consist of mechanical, optical and electronic engineers in addition to astronomers having experience in the fabrication of astronomical instruments.

The function of the instrumentation cell will be to develop instruments for optical astronomy. The expertise developed over the years at IIA would be available to users from institutions/universities desirous of building their own instruments for use with VBT or any other telescope. It is planned to provide assistance in two stages : (1) Preparation of conceptual designs based on the scientific requirements provided by the user. This includes advice on the possibility of indigenous fabrication, and further, the preparation of mechanical, optical and electronic design papers for the instrument. The cell would also try to provide information on procurement of components: their estimated costs and sources. Budgetary estimates for instrument fabrication could be provided too. (2) If the user wishes the instrumentation cell to get the instrument fabricated under its supervision, the cell will take up the job.

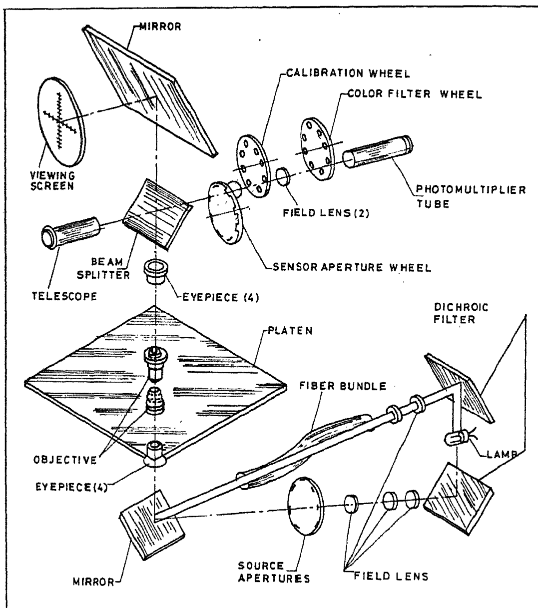
The constitution of the advisory committee for the National Facility is under way. Proposals received in the meanwhile will also be promptly attended to. I hope that the establishment of the National Facility would mark an important stage in the development of optical astronomy in India.

J. C Bhattacharyya

facilities

PDS Microdensitometer

The Perkin-Elmer PDS (Photometric Data System) Model 1010M Microdensitometer is now installed. It is designed to take accurate readings on very small areas of a photographic plate or film (hereafter called specimen) at precise locations. The high precision and measuring speed of this machine, and the automatic nature of its operation make it a valuable tool for the evaluation of photographic records of data.



THE PATH OF LIGHT THROUGH THE PDS MICRODENSITOMETER

The model 1010 M Microdensitometer consists essentially of three systems. One to measure the density or transmission information, the second to move the stage in either or both orthogonal (X and Y) directions, and the third to generate the precise information on stage position. Incandescent light is projected through a source aperture and focused on to the emulsion of the photograph to be digitized. This pre-aperture minimizes stray light in the optical system by restricting the area of the emulsion being illuminated. The light from the illuminated portion of the specimen, after passing through another sample-defining aperture (called sensor aperture), is imaged on to a photomultiplier tube. The size of this aperture, divided by the overall microscope magnification determines the size of the picture element used in digitizing the photograph. The intensity of the light falling upon the photomultiplier tube, and hence its output signal, is proportional to the transmittance of that area of the emulsion defined by the sampling aperture. When the photograph is moved, an analog signal is generated due to variations in the transmittance of the photographic emulsion. This signal is sampled and digitized as a function of the stage position, thus creating a numerical image which can be stored on magnetic tape for subsequent processing.

The microdensitometer can accommodate and digitize a maximum area of 25 cm × 25 cm at a maximum scan velocity of 50 mm per second. The glass platen on which the specimen is held can be rotated manually through 360 degrees, thus facilitating an accurate alignment of scanning direction.

The stage position along each axis is monitored with a precision of 1 μm using linear optical encoders. The overall positioning accuracy is 5 μm over the full 25 cm of travel. Eight selectable apertures and four selectable magnifications provide a variety of pixel shapes and sizes over a range of 5-400 μm. Full-field specimen viewing arrangement is provided for, as also the microscopic viewing of the region centred for the beginning of a scan. However, the viewing is done only when digitization is not in progress.

A set of neutral-density filters help in the selection of the optimal range of light level at the photomultiplier for a given size of sampling aperture, and the range of densities of interest. A set of colour separation filters is also available.

The microdensitometer output consists of stage positional information and pixel transmittance, optionally in units of density, covering a density range of 0 to 5.11.

Scanning parameters like the resolution, number of pixels, mode of scanning etc., are operator-selectable as inputs to the controlling microprocessor (Z 6802). In the automatic mode of scanning, the processor will control all microdensitometer operations. It will continually monitor the X and Y stage positions, initiate analog to digital conversions and store the information. The digitized data can, on command, be stored on magnetic tape, plotted on a strip-chart recorder or printed out at the console terminal.

The model D1010A photographic playback system provides the facility to generate photographic images from digital images stored on the magnetic tape. A red LED (light-emitting diode) light source is used to expose the film or plate placed on the microdensitometer stage.

PDS Model 1010M

Specifications

Stage travel, each axis	: 25 cm
Maximum velocity, each axis	: 50 mm s^{-1}
Positional accuracy, both axis	: ± 5 μm
Repeatability, each axis	: ± 1 μm
Resolution, each axis	: 1 μm
Platen rotation	: 360°

Photometer

Hamamatsu	: R 268 PMT
Response	: 300 to 650 nm
Dark current	: 0.2 NA
Max. current	: 100 μA

Illuminator

150 W Tungsten	: Halogen lamp
Color temperature	: 3244 K

Optics

Objective	: 10 × .25 NA achromat
Resolution	: 900 L—P mm^{-1}
Depth of Focus	: ± 4.4 μm
Eyepieces	: 5 ×, 10 ×, 15 ×, 20 ×

Nominal apertures and magnifications

Magnifications		Apertures	
Objectives	Eyepieces	Sensor apertures in mm	
1. 10 ×	1. 5 ×	A. 1.0 Dia.	E. 0.5 × 20
	2. 10 ×	B. 1.0 Sq.	F. 1.5 × 20
	3. 15 ×	C. 2.5 Sq.	G. 2.5 × 10
	4. 20 ×	D. 0.5 × 10	H. 2.5 × 20
		Source or Playback apertures in mm	
1. 10 ×	1. 5 ×	A. 1.5 Dia.	E. 1.0 × 21
	2. 10 ×	B. 1.5 Sq.	F. 2.0 × 21
	3. 15 ×	C. 3.0 Sq.	G. 3.0 × 11
	4. 20 ×	D. 1.0 × 11	H. 3.0 × 21

Nominal pixel sizes in microns

Sensor Apertures	Magnification			
	1 (50 ×)	2 (100 ×)	3 (150 ×)	4 (200 ×)
A	20 Dia.	10 Dia.	6.67 Dia.	5.0 Dia.
B	20 Sq.	10 Sq.	6.67 Sq.	5.0 Sq.
C	50 Sq.	25 Sq.	16.7 Sq.	12.5 Sq.
D	10 × 200	5.0 × 100	3.3 × 66.7	2.5 × 50
E	10 × 400	5.0 × 200	3.3 × 133.3	2.5 × 100
F	30 × 400	15 × 200	10 × 133.3	7.5 × 100
G	50 × 200	25 × 100	16.7 × 66.7	12.5 × 50
H	50 × 400	25 × 200	16.7 × 133.3	12.5 × 100
Source or Playback Apertures				
A	30 Dia.	15 Dia.	10 Dia.	7.5 Dia.
B	30 Sq.	15 Sq.	10 Sq.	7.5 Sq.
C	60 Sq.	30 Sq.	20 Sq.	15 Sq.
D	20 × 220	10 × 110	6.67 × 73.3	5.0 × 55
E	20 × 420	10 × 210	6.67 × 140	5.0 × 105
F	40 × 420	20 × 210	13.3 × 140	10 × 105
G	60 × 220	20 × 110	20 × 73.3	10 × 55
H	60 × 420	30 × 210	20 × 140	10 × 105

Ram Sagar

The VAX 11/780 system at the 2.3 m Vainu Bappu Telescope

During the conception of the 2.3 m Vainu Bappu telescope, it was realised that a powerful computer system would be needed on-line to the telescope, in order to acquire and reduce data from the new generations of detectors to come. The system would also be required to perform some of the functions associated with the control of large telescopes.

With the evolution of the design of the control system of the telescope, it became clear that a powerful computer system capable of doing fast data acquisition, reductions and analysis could not be used effectively if it were directly involved in the control system, where it would have to process interrupts every few milliseconds. The decision was thus taken to have a microprocessor directly supervising the control system : to read the telescope encoders, control and update the position displays and perform other housekeeping functions in the control system. The microprocessor would be linked to the main computer, which would hold the large catalogues of celestial objects and perform only the more complex tasks associated with telescope control i.e. retrieval of object coordinates from catalogues and corrections for coordinates including telescope flexure models.

In 1979, the newly announced VAX 11/780 system was selected as the system most suited for the 2.3 m telescope. The process of obtaining the necessary clearances was started and the order finally placed in February 1982. The system arrived in India starting April 1984 and the VAX system itself was operating by the end of July 1984. The COMTAL imaging system, the Tektronix graphics system and other peripherals were installed and operating in the subsequent one year.

VAX configuration : The system was configured keeping in mind the tasks of real-time data acquisition as well as (sometimes simultaneous) off-line reductions and analysis. The highlights are :

3 Mbytes of memory on two controllers (1.5 Mbytes each)

First MASSBUS—Disk drives RM80 (124 Mb), RM05 and RM05 (300 Mb each)

Second MASSBUS—Tape Drives TU77 (800/1600 bpi) and TU78 (1600/6250 bpi)

First UNIBUS—VT 100 and VT 240 series terminals

PRINTRONIX 600 printer/plotter

Card reader

LPA 11K Direct Memory Access controller with two 16-bit parallel I/O (DR11KT) cards and one real time clock card

Tektronix 4115 B high resolution graphics terminal
Tektronix 4691 colour copier

Second UNIBUS—CAMAC system interface

Third UNIBUS—COMTAL Vision One/20 Image Processing System (It has not yet been possible to acquire an array processor as initially planned for this UNIBUS)

The LPA 11K DMA controller is the interface between the VAX and the telescope control system microcomputer (Intel 86/14). A 16 bit parallel I/O port (DR 11K) on the LPA 11K bus caters to communication between the two systems.

The high resolution Tektronix 4115 B graphics system features a resolution of 1024 x 1280, and in its present configuration has 544 Kbytes of local memory plus 4 bit planes for up to 16 displayable colours (from a palette of 16 million). The interface to the VAX is a 16 bit parallel DMA interface. The Tektronix 4691 colour copier is normally used connected to the 4115 B for off-the-screen copies on plain paper. There is also a parallel interface for the copier on the UNIBUS, which, when used with rasterising software enables copying of VAX files directly.

The COMTAL Vision One/20 system has 4 image planes of 512 x 512 x 8 bits each and 4 graphics planes of 512 x 512 x 1 bit. The system is highly interactive and can also be used in the stand-alone mode of operation (there are however no storage drives local to the COMTAL in the present configuration for retrieving/storing images in this mode). The system features real-time (1/30 of a second) image arithmetic, local zooming and panning, real time histograms of images and local software convolution.

The CAMAC system interface is the 'GEC-Elliot executive suite' hardware system, which can cater to upto seven CAMAC branches (parallel, serial or mixed). CAMAC crates on these branches (dataways), would be located at the foci of the telescope. The CAMAC system would be used to interface instruments and detectors to the VAX.

The Graphic/Display Libraries

Four software packages are available for graphics/display at the VAX 11/780 system at Kavalur:

1. COMTAL software allows transfer of digital images and their processing on the COMTAL Vision One/20 system, *via* calls from user programmes. The Graph-S option permits simple yet powerful operations using the 4 graphics planes. The standard firmware allows simple arithmetic between images, and the CONVL-S option can be used for software convolution of images with specified kernels.
2. The DIGITAL Re GIS Graphic Library (RGL) provides several commands for graphic action, as well as FORTRAN subroutines which may be directly called for graphic display. Re GIS is an acronym for Remote Graphic Instruction Set. The commands and routines can be used with VT 125 or higher versions of Video terminals. At present one VT 125 (monochrome) terminal, and two VT 241 (colour) terminals support RGL.
3. The Tektronix 4010 C01 PLOT 10 Interactive Graphic Library (IGL) can be used on the Tektronix 4115B graphics terminals. The primary command set is available, and can be used in FORTRAN programmes to generate graphic input/output. 3-D graphics support will be implemented in the near future.
4. DIGITAL PLXY-11 software package contains FORTRAN callable routines which lend the basic plotting capability to the PRINTRONIX 600 printer/plotter.

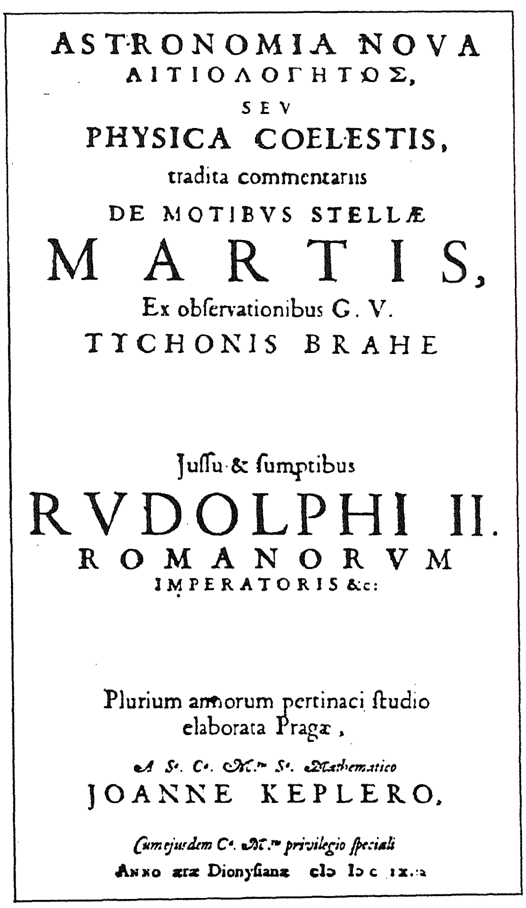
Ashok Pati

Indian Institute of Astrophysics Library

1. The Historical Collection

The Institute library is nearly as old as the observatory itself (~200 years). It has been continuously acquiring astronomical literature, in the form of books, journals and catalogues, since the beginning of the 19th century and today it can boast one of the best collections in the subject. A library catalogue for the years 1794—1812 is still available as a part of the Madras observatory reports, which were hand-written by calligraphers as was the practice at the time. According to this catalogue, there were 102 books and journal volumes and 52 manuscripts in 1812. Some of the original books/journals listed are available with the library and will be on display during the Bicentennial Celebrations this December; unfortunately, only a few manuscripts are available.

The oldest book in the library is *Stellae Martis* written by Kepler in Latin, and published in 1609. The library has about twenty books published in the 18th century, including Flamsteed's *Historiae Coelestis* in three volumes (1725), original astronomical observations made by W. Wales during the course of his attempted voyage to the South Pole, published during the last quarter of the 18th century, and a history of royal society by Sprat published in 1734. The oldest journal volume is the *Philosophical Transactions* of 1794, and the oldest almanac available is for the year 1767. The library also has Greenwich astronomical observations made since 1765. Another valuable collection is the annual report of Madras observatory for the year 1792.



ASTRONOMIA NOVA
ΑΙΤΙΟΛΟΓΗΤΟΣ,
SEV
PHYSICA COELESTIS,
tradita commentariis
DE MOTIBVS STELLÆ
MARTIS,
Ex obſervationibus G. V.
TYCHONIS BRAHE
Juſſu & ſumptibus
RVDOLPHI II.
ROMANORVM
IMPERATORIS &c:
Plurium annorum pertinaci ſtudio
elaborata Pragæ,
A S. C. M.tis S. Mathematico
JOANNE KEPLERO,
Cum ejusdem C. M.tis privilegio ſpeciali
Anno æræ Dionyſianæ CIↃ IↃ C IX.

Title page of *Stellae Martis* by Kepler (1609).

Another library catalogue maintained in 1893, is an improvement on the earlier catalogue. In this, entries were made according to a dictionary format giving each book an entry both by its author and subject, and sometimes also under the name of the observatory from where it was published. Much care was taken in the preparation of this catalogue giving appropriate cross-references wherever necessary. There were 440 books and astronomical catalogues available in the library which were published in the 19th century. It also received 105 observatory publications and 31 journals through exchange and subscription which constituted the core of all the observatory publications and journals published at that time. Continuous runs of many astronomical journals like the *Monthly Notices of the Royal Astronomical Society,* the *Astrophysical Journal,* the *Publications of the Astronomical Society of the Pacific,* and the *Observatory* are available from volume 1 onwards. Some interesting publications of the 19th century include Goldingham's astronomical observations made at the Madras Observatory, volumes III and IV, Taylor's *General Catalogues of Stars,* Pogson's catalogues of variable stars, Laplace's *Mecanique Celeste* in 6 volumes, Lockyer's 4 volumes including *Recent and Coming Eclipses* and a history of astronomy by Narrien.

When the observatory was shifted from Madras to Kodaikanal in 1898-99, the then director Michie Smith took ample care that the books should be sent up the 'Ghaut' road in dry weather. The packing was done before December and by the end of March the whole transfer was made. The director's report for 1898-99 says "all cases of books were received before the rain began and on the whole the removal has been effected with remarkably little damage considering the difficulties that had to be overcome".

In 1901 a binding section was attached to the library and a 'book-binder' and a 'book-binder's boy' were appointed. It is said that in the years to come, the book-binder's son and grandson were also employed in the observatory's binding section and the family carried on this profession until the grandson (Mr. Veeraraghavan) retired in 1975.

Till the appointment of a librarian in 1974, the library was managed by various staff members. The annual report for the year 1907 says that Mrs. Evershed (wife of John Evershed who was then the assistant director of the observatory), took a keen interest in the library and was responsible for completing a card catalogue of the books. She took a keen interest in astronomy too. One of her books titled *Dante and the Early Astronomers* (1913) is available in the library.

A. Vagiswari & Christina Louis

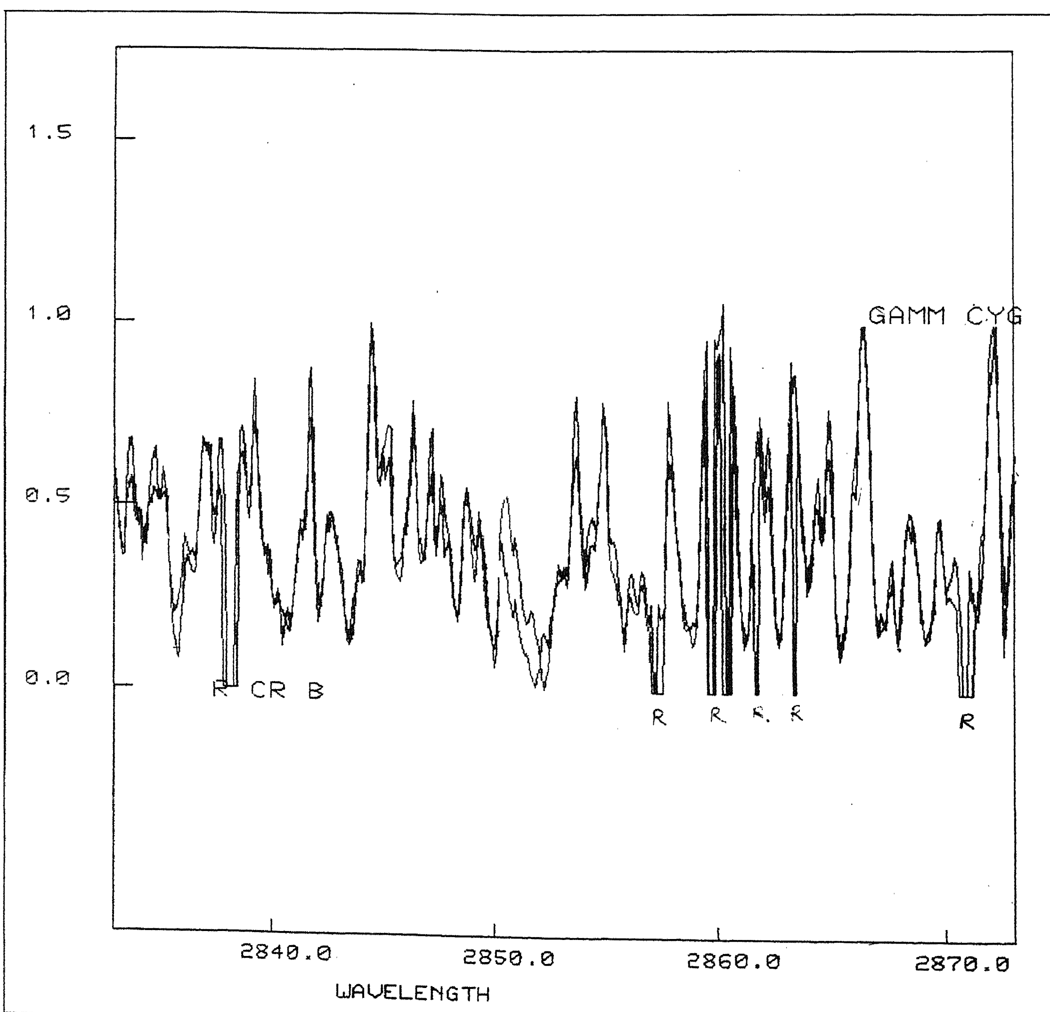
research

IUE Data Reduction

IUE satellite has been operational since 1978 and has been producing spectra of astronomical sources in the wavelength range 1175 to 3200 Å. All these data are stored in IUE archives at the World Data Centre and other places and are accessible to astronomers all over the world. However, proper reduction and processing of software is required to utilize them. We have recently made the IUE data reduction programmes (IUEDR, IUE, DIPSO) of STARLINK package, operational on the VAX-11/780 system at Kavalur.

It is now possible not only to extract the flux-calibrated spectrum from the data tapes but also to effect many operations related to further processing (e.g. adding and subtracting spectra, smoothing).

The figure on the front page of this *Newsletter* illustrates the spectra of R Cr B and γ Cyg (both F8 supergiants) obtained by one of us while using IUE satellite in the high-resolution mode (~0.6 Å). The main purpose was to isolate and study the emission features in the centre of the strong absorption lines in R Cr B with the aim of understanding the phenomenon of mass loss and of chromospheric activity. As is well known, many of the important spectral lines needed for such a study (resonance lines of neutral and singly ionized metals like Mg II, Fe II, Fe I, Mg I) occur in the ultraviolet. The figure shows one of the echelle orders of the spectrum for each star containing the λ 2852 Mg I line. γ Cyg (F8 Ib) is a good match to R Cr B both in its spectral type and in the characteristics of the absorption line spectrum except for the emission features in the R Cr B spectrum. To bring out these, we extracted the spectra using IUEDR program and converted them into continuum units. The normalized (to continuum) spectra of both stars were 'matched', by subtracting one from the other. The illustration was prepared using the display program developed by T. P. Prabhu and G. C. Anupama. The difference spectrum shows the Mg I λ 2852 with the P-Cygni type profile with two absorption components occurring at −53 and −171 kms^{-1} relative to the emission. Similar profiles are also seen in the lines Fe II, Mn II etc. These will be used to estimate the rate of mass loss for R Cr B.



The spectra of R Cr B and γ Cyg superposed. The place of Raseau marks are indicated with R. Except in the region of Mg I λ 2852, the two spectra match very well.

N. Kameswara Rao & Sunetra Giridhar

Advent of Modern Astronomy in India

As the East India Company's non-trading activities increased, so did its need to understand the geography of the country. Many officers of the company on their own initiative and for their personal amusement made astronomical observations. Of course, whereas latitudes could be determined absolutely, longitudes were only relative ; it was not till the foundation of the Madras Observatory, that longitudes could be referred to Greenwich.

In the early days, it was not the company's policy to supply the officers with surveying instruments ; those interested had to get them on their own. In course of time, however, the government did build a small stock of the more common instruments.

The most notable of early astronomers in Bengal were the Reverend William Smith, and Thomas Deane Pearse of the Artillery. Smith was an enthusiastic astronomer. He came to Calcutta as a private tutor, not as a company employee. Earlier, with his 'short and correct method of determining the longitude at sea, by a single altitude of the Moon', he had laid claims to the British government reward, which eventually went to John Harrison. For two years starting from 1775 Smith measured longitudes and latitudes of many places including Bombay, Cochin, and Calcutta.

Pearse commanded the Artillery in Bengal from 1768. He was a competent astronomer and built a private observatory at his residence at the Treasury Gate, Fort Williams, Calcutta, where he made regular astronomical and meteorological observations. A continuous series of his observations 1774-1779 for latitude and longitude were published in *Asiatic Researches* (Vol. 1, pp 47-109), where he also described his instruments.

The most outstanding of the early Bengal astronomers was Reuben Burrow who arrived in Calcutta in 1783. Already 35 years old, he had at one time been assistant to Nevil Maskelyne, the Astronomer Royal, and then for six years mathematical master to the artillery cadets at the Tower of London. While at the Tower, he was employed by the board of ordnance to make a survey of the coast of Essex and Suffolk, and also of the Woolwich Warren.

Burrow was greatly interested in Hindu astronomy and was most anxious to be sent to Benares to get in touch with the pundits there. He also wanted to use JaiSingh's observatory at Benares :

'Fortunately for Astronomy there is a large Quadrant existing at Benares, which from the intent of its construction must necessarily have been placed in the plane of the meridian when the observatory was erected... and as this Quadrant is an immoveable structure of solid masonary...the transits and altitudes of a number of stars may be taken with it, by a proper contrivance'.

Reuben Burrow had suggested to Warren Hastings the setting up of an observatory to make corresponding observations with a view to accurately determining the longitudes. Hastings was interested and asked Col. Watson to give an estimate of the expense involved. But unfortunately for Burrow and astronomy, Hastings left early in 1785, and his successors were simply not interested. When Burrow revived his proposal in 1789 for an observatory, he was roundly snubbed, the directors writing in 1790:

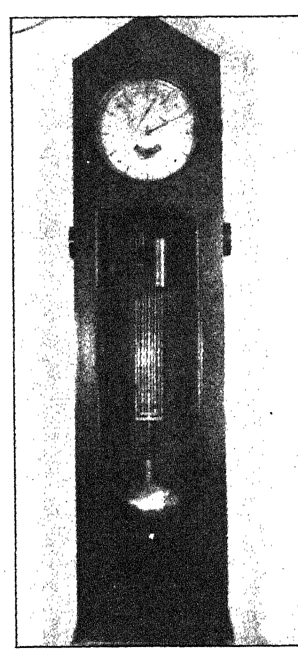
'...we mean that the operations in India, whether astronomical or geographical, should be confined to *actual* observations only, leaving the comparisons and results to be made in England, where it can be done more effectually, at much less expense...,

Mr. Reuben Burrow's representing that there is no instrument sufficient to determine the place of a star, whereby many occultations of undetermined stars, are useless, is a strong argument why he should have sent these observations home.'

In this respect, Michael Topping at Madras was more fortunate, because one of the members of the Madras council, William Petrie, was a keen astronomer himself, and gave Topping his strong support and assistance. Petrie had set up a private observatory at Madras in 1786. He permitted Topping and his assistant John Goldingham to make correspondent, simultaneous observations at his observatory. When Petrie left for England in 1789 he offered his observatory as a gift to the government, and Topping pressed for the acceptance of the gift:

'The Astronomical observatory built by William Petrie Esq. for his own private use but which by his permission... has since the commencement of my operations, been occupied in the public service... is in danger of being no longer accessible'.

'Mr. Petrie... very liberally assured me that the building... was at my entire disposal for the public service, and that I was at liberty to remove it... the principal materials of which it is constructed are of a nature to be removed without the least injury to them ;... the whole may be rebuilt at an inconsiderable expense...'



Grid-iron pendulum clock by John Shelton, identical to the ones used by James Cook in his 1769 transit of Venus expedition. Presumably acquired by William Petrie when he visited England in 1782, it was a part of the observatory he set up. It is at present at Kodaikanal and in use.

The board asked Topping to suggest a place for the new observatory, and forwarded his proposals to the company directors, while Lennon carried on at Petrie's observatory.

In 1790 the directors agreed that 'the establishment of an observatory at Madras would be of great advantage to science'. Topping purchased one Mr. Edward Garrow's house (College Road, Nungambakkam, Madras). A storey was added to the residence, and the observatory building constructed in 1792 in the grounds.

R. K. Kochhar

of human elements

Sad tail of a Comet

Considered the greatest of comet hunters, he [Charles Messier] was obsessed with finding them. Unfortunately, around the time of the return of Halley's Comet in 1763, his wife had the misfortune of coming down with a fatal illness. While Messier was busy nursing his wife, his arch-rival, Montaigne of Limoges, found a most important comet. At his wife's funeral, when someone offered condolences, Messier, beside himself with grief, could only utter: "Yes, it is too bad. He has robbed me of my thirteenth comet!" Then, realizing what he'd said, he quickly added, "Ah, poor woman!"

Not long after the funeral, Messier was walking in his garden and constantly gazing at the sky on the off-chance of spotting a comet. Instead he fell headlong into a well, was nearly killed, and spent the next several months in the hospital.

John Tullius in 'Book of Halley's Comet'

Avon, USA, 1985

out of context

I should like to turn now the WR stars.

Mem. Soc. R. Sci. Liege

(1975) No. 8, Vol. 9, p. 202

* *

In addition to its uniqueness as an astronomical object, the Sun is the source of life giving energy for man.

The Solar Chromosphere and Corona: Quiet Sun

(1976) D. Reidel, Dordrecht, p. 2.

* *

Computations for a system with 10^7 stars were also carried out by Sanders, extending over a period of 1.4×10^8 years.

Nuclei of Galaxies

(1971) North-Holland, Amsterdam, p. 466.

Indian Institute of Astrophysics bicentennial symposium (5-6 December 1986) will be held at the Guru Nanak Bhavan, the newly built Karnataka government auditorium, on Miller's Tank Bed, Bangalore 560 052.

As part of the bicentennial celebration an astronomy quiz on television has been arranged for science and professional graduate students from Bangalore and neighbourhood colleges. An all-India essay competition is also being organized. The prize winning teams would be given 7.5 cm telescopes and books on astronomy.

On 6 December 1986 there shall be a scientific visit to the Vainu Bappu Observatory, Kavalur.

The symposium marks the beginning of an 'astronomy year' celebrations.

Guru Nanak Bhavan will be the venue for the tenth meeting of the Astronomical Society of India, 7-9 December 1986.

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