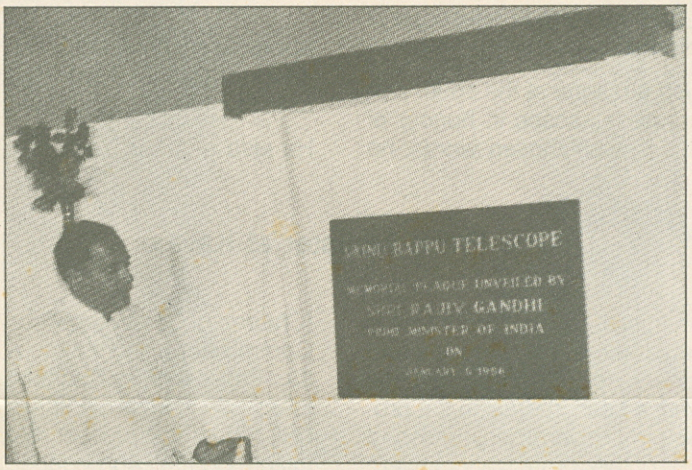
Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics

Volume 1 Number 2 April 1986

Kavalur Observatory and 2.3 m Telescope named after Vainu Bappu



At a brief ceremony on 6 January 1986 the Prime Minister Mr Rajiv Gandhi named the Kavalur Observatory and its 2.3 m telescope after late Professor M. K. Vainu Bappu, who had created the observatory, and was the mastermind behind the design and fabrication of the telescope. The ceremony was arranged on the observing floor of the 2.3 m telescope dome.

In his opening remarks, Professor J. C. Bhattacharyya gave a brief outline of the life of Vainu Bappu. He narrated how Vainu Bappu chose to return to India after his doctoral and post-doctoral work in the United States, at a time when facilities in astronomy were lacking in India; how he influenced the modernization of the Nizamiah Observatory Hyderabad; how he led the new astronomical venture of U.P. State and created its observatory at Naini Tal; and how he expanded the Kodaikanal Observatory resulting in IIA and created the Kavalur Observatory culminating in the design and fabrication of the 2.3 m telescope.

Vainu Bappu chose the site in Javadi Hills near Kavalur village in the 1960s after a detailed survey of southern India. A 38 cm reflector made in the workshop of Kodaikanal observatory was moved to the location in 1968. The 1 m Carl Zeiss reflector was installed in 1972. Thereafter, Vainu Bappu finalized the plans for the 2.3 m telescope and undertook another site survey before he decided that Kavalur is good enough a site even for this larger telescope. He supervised the design and fabrication of the telescope at every stage until his death in August 1982. Numerous institutions and industries were involved in the design and fabrication at different stages. The important ones being the Tata Consulting Engineers, the Walchandnagar industries, and the Bhabha Atomic Research Centre.

Bhattacharyya recalled that Vainu Bappu adored relics of great events and personalities who have enriched human culture and civilizations; that he believed that memorable achievements of the past by any particular individual or institution always inspires future accomplishments. Bhattacharyya, with his faith in this idea, confidently looked forward to further achievements inspired by the memory of Vainu Bappu.

Professor M. G. K. Menon requested the Prime Minister, on behalf of the Governing Council and the staff of IIA, to name the Kavalur Observatory and the 2.3 m telescope in honour of Vainu Bappu. He noted that the history of IIA dates back to two centuries. William Petrie, an official of the British East India Company had set up a private observatory in 1786 which he handed over to the Company in 1789 before leaving for England. This Madras Observatory found Kodaikanal a better astronomical site and moved over in early years of this century. Vainu Bappu was appointed as the Director of Kodaikanal Observatory in 1960 and founded the Indian Institute of Astrophysics in 1971.

Menon paid tributes to the versatility of Vainu Bappu's interests and abilities, multiplicity of his achievements, and his human qualities of dignity and kindness. He appreciated the able assistance of Mr S. C. Tapde, the Project Manager, and Mr A. P. Jayarajan, the optician, in Vainu Bappu's endeavour of fabricating the 2.3 m telescope. He noted with content that since Vainu Bappu returned to India, when the facilities in the country for astronomical research were few, we have come a long way. Among the existing and emerging facilities are the optical observatories at Kavalur, Japal-Rangapur and Naini Tal, the Ooty Radio Telescope, and the Giant Metre-wave Radio Telescope of the Tata Institute of Fundamental Research, the Millimetre-wave telescope of the Raman Research Institute, and the 1.2 m IR telescope of the Physical Research Laboratories.

The Prime Minister then unveiled a plaque at the south pier of the 2.3 m telescope, naming the telescope in honour of Vainu Bappu. In a few simple and well-chosen words, he appreciated the inspiration provided by Vainu Bappu through his achievements and called upon other scientists to follow his example.

He also met Mrs Yemuna Bappu.

Transcript of the Prime Minister's Speech

Shri Menon, Shri Bhattacharyya, distinguished guests, friends. It gives me a great pleasure today to dedicate this centre and this telescope in the memory of Shri Vainu Bappu. Shri Vainu Bappu inspired Indian Astronomy. Invariably, when a country looks towards new areas of development, it is the inspiration from an individual which gives the direction. We have seen that happen in our other scientific fields as well. For Indian astronomy, Vainu Bappu gave that inspiration. And this centre, this telescope, will carry on the tradition that he laid; tradition of quality, of seeking the best that human efforts could avail. We have seen how he made a name for himself not only in India but amongst the top astronomical circles in the world. Today, we hope that his example will show the way to many more scientists to come back to India; to scientists who are already in India, to give the type of lead and direction that Vainu Bappu gave. It is a pleasure to have Smt Bappu with us today. I hope that this telescope, our astronomers, will rise to greater heights, will strive towards the forefront of knowledge in astronomy and astrophysics and put India where it belongs, where it used to be, hundreds of years ago.

Thank You.

The Prime Minister at Kavalur

The recent visit of the Prime Minister Rajiv Gandhi to the Observatory at Kavalur provided some of the scientists and technicians of IIA with an opportunity of interacting with this charming softspoken person with a keen interest in the promotion of science and technology. Several distinguished scientists and technologists from other organizations were also present at this occasion – Professor M. G. K. Menon (Chairman, Governing Council of IIA, and member, Planning Commission), and the members of the Governing Council of IIA: Professors V. Radhakrishnan (Raman Research Institute), S. K. Trehan (Panjab University), N. A. Narasimham (INSA Senior Professor, IIA), George Joseph (Space Application Centre, Ahmedabad); Professors U. R. Rao (Chairman, Space Commission), G. Swarup (Radio Astronomy Centre, TIFR), Anna Mani (Indian Institute of Tropical Meteorology), late S. N. Seshadri (Bhabha Atomic Research Centre), D. Easwara Das (Vikram Sarabhai Space Centre), N. V. G. Sarma (Raman Research Institute), and Mr V. L. Doshi (Walchandnagar Industries Ltd.). The Tamil Nadu State Government was represented by Shri Nedunchezhiyan, Finance Minister.

The Prime Minister in the prime focus cage of the Vainu Bappu Telescope.

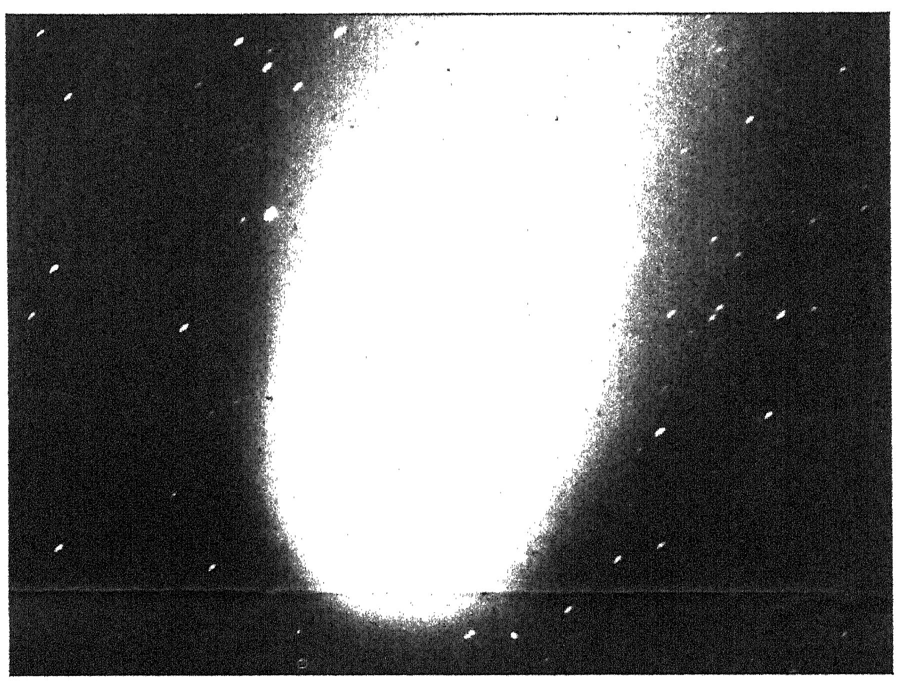
The Prime Minister arrived punctually at 4.30 p.m. in a helicopter from Bangalore. He proceeded directly to the observing floor of the 2.3 m telescope. After the ceremony, he released a brochure on IIA, and proceeded to visit the VAX 11/780 computer. After sunset he went over to the 1 m reflector to fulfil the prime interest of his visit to Kavalur — to observe Comet Halley. He looked also at the Orion Nebula, Crab Nebula, Jupiter with its moons, double stars and star clusters, and learnt about the astronomical scales of distance and time. At a buffet dinner, he discussed with scientists topics such as the nature of the comets, astronomical education in the universities, and the Giant Metre-wave Radio Telescope. He also showed interest in the history of IIA and on how astronomers prepare their observational programmes.

After dinner, he visited the satellite tracking and ranging station of the Department of Space, situated in the campus of the observatory. He exhibited a keen interest in the time signals used as reference and accuracies of the clocks used in ranging, displaying his deep knowledge in the field acquired during his association with modern aviation. He then moved over to the 2.3 m telescope, climbed into the prime focus cage, and viewed some star fields. A look at the Orion Nebula gave him an opportunity of appreciating the increased light-gathering power. He spent a considerable time discussing the optical and mechanical aspects of the telescope with technicians.

After the several hours he spent at the observatory, Mr Rajiv Gandhi left a deep impression of a Prime Minister who understands and cares for science. His inquisitiveness ranged from meteorites to the ages of stars, from pulsars to black holes, from time signals to the mechanical stability of the telescope.

The Prime Minister's visit has certainly made the Vainu Bappu Observatory a spot of visitor's interest. In the subsequent months it has drawn not only VIPs like the Air Chief Marshal, and scientists and engineers in charge of national scientific endeavours, but also students of all age groups, and crowds of laymen from nearby towns and villages. As far as such visits increase an awareness of astronomy among the scientists from other disciplines, the beaurocrats, students and the general populace, the observatory does not discourage the visitors. Of course, one has had to restrict the vehicular traffic in the campus at night so as not to disturb the observations. On the other hand, a team of assistants have taken it upon themselves to educate the visitors on the secrets of the universe. A 6-inch telescope which belonged personally to Vainu Bappu is kept busy with this task.

from the director



A 6-minute photogragh of Comet Halley obtained at the prime focus of the 2.3 m telescope on March 11. Kodak 098-02 emulsion; no filter.

The Vainu Bappu telescope, so named by the Prime Minister on 6 January 1986, has commenced prime focus photography while adjustments for fine tuning of the drive system continue. The large dynamical range of telescope movements demanded by the users created problems at the two extremes which have been solved by splitting the operable range in two parts. A larger capacity of power amplifier also needed for this, will be provided for in near future.

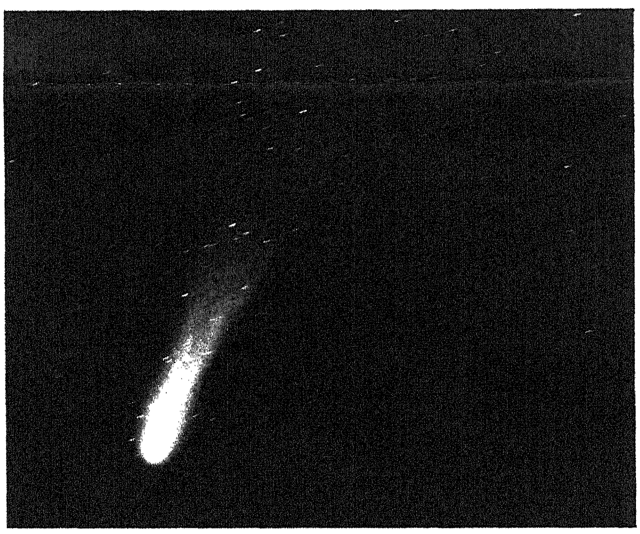
The Wynne corrector, built in our laboratories, has been installed at the prime focus, and hence the usable field is expanded. Photographs of several objects have been taken, not the least among them being our celestial visitor, Comet Halley. The makeshift arrangement of a shutter and a plate holder has been replaced by a regular camera with fibre-optic image-guiding system.

The design papers of a prime-focus photoelectric photometer are ready and the fabrication of mechanical parts started. In a few months time this will be the most powerful detector system available for the study of faint objects.

J. C. Bhattacharyya

45 cm Schmidt Telescope

The mechanical assembly of the new 45/60 cm Schmidt telescope was hastened to commence observations of Comet Halley. The optics of the telescope, fabricated in the laboratories of IIA, consist of a 60 cm *F*/2.245 primary and a corrector plate of 45 cm diameter. A field flattener of clear aperture 100 mm x 125 mm is placed in front of the focal plane so that flat photographic plate can be employed. The image scale is about 2.5 arcmin mm^{-1} resulting in a flat field of about 4° x 5°. Unvignetted field of the telescope is, however, little over 3°. With a larger field flattener, one may, in future, be able to photograph the entire corrected (but vignetted) field of 6° diameter.



A 33 minute photograph of Comet Halley obtained with the 45 cm Schmidt on March 20. Kodak 103a-O emulsion + Wratten 47A Filter.

Infrared Photometer

An InSb infrared detector system has been acquired from the Infrared Laboratories Inc., Tuscon. The liquid-nitrogen cooled system consists of a set of JHKLM filters and two circular variable filters (1.2-1.6μm, 1.5-3.9μm) driven by a stepper motor. The optical assembly including a vibrating mirror chopper has been fabricated in the mechanical shop of the Institute. The infrared photometer is undergoing installation tests for use on the 1-m reflector.

PDS Microdensitometer

The microprocessor-controlled PDS 1010MS microdensitometer has just been acquired. A major part of the consignment has already arrived. Arrangements are being made for its installation at Bangalore.

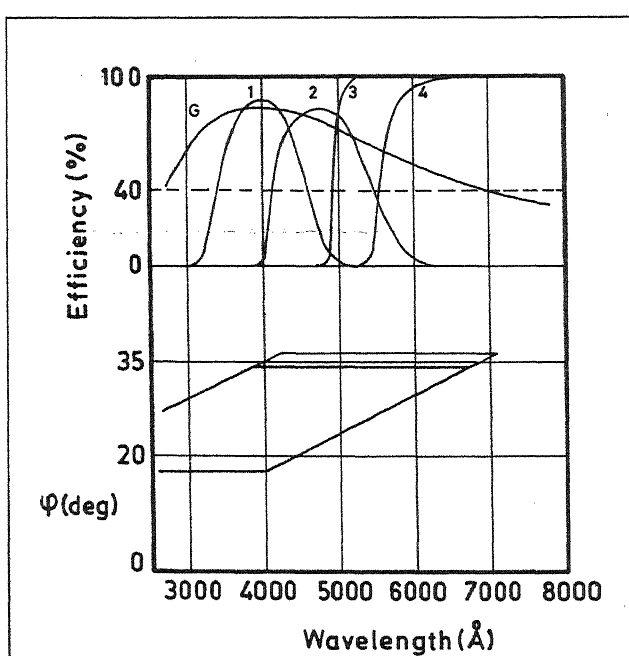
The basic unit includes Perkin-Elmer G1010A photometer (0-5D), R100A stripchart recorder, DEC LA120 high-speed hardcopy terminal, a dual-density 800/1600 bpi magnetic tape drive and controller, and a power control/protection system with a capacity for 30 min uninterrupted power supply. In addition, the Perkin-Elmer D1010A photographic playback unit and A1010A film attachment unit have also been acquired.

A New Cassegrain Spectrograph for the 1-m Reflector

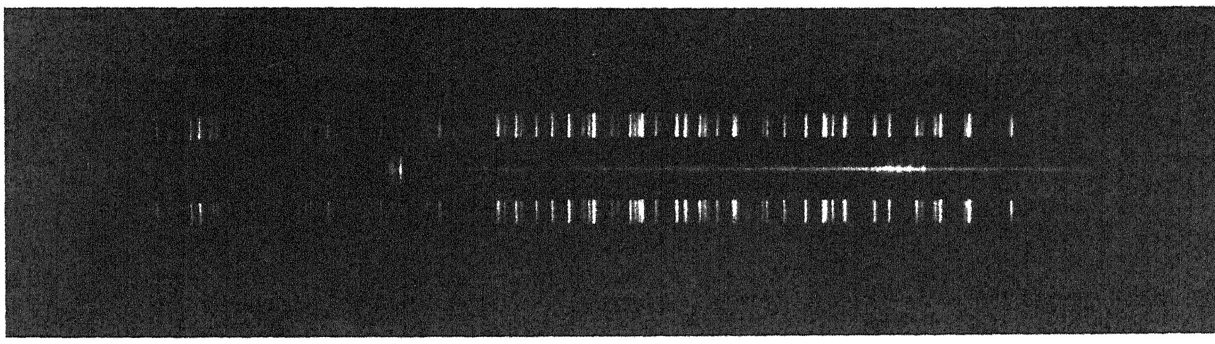
A Universal Astronomical Grating Spectrograph (UAGS) from Carl-Zeiss, Jena was recently acquired for use with the Cassegrain *F*/13 focus of the Kavalur 1-m reflector. Its installation and testing took place on 22 February when a blue spectrum of Comet Halley was obtained.

The choice of this spectrograph was made based on various factors, including its low cost and compactness. It can be adapted to different beams (*F*/4 to *F*/18) by changing only the collimator optics. We have acquired the catadioptric *F*/13 collimator system. The spectrograph is particularly suitable for intermediate light levels. The dispersion can be varied by changing the grating or the camera. At present, only one grating is available : 651 l mm^{-1} with a blaze angle of 8°. The peak efficiency of the grating is about 85 per cent at 4000 Å and falls to 40 per cent at 2800 Å and 7000 Å. Two Schmidt cameras of focal lengths 110 and 175 mm are available yielding dispersions of 136 and 86 Å mm^{-1}, respectively in the first order up to 7000 Å.

The spectrograph has a field-viewing arrangement which helps in acquiring visually objects as faint as 15 mag on the 1-m reflector. The diameter of this field is 8 arcmin. The slit jaws are made up of hardened chromium-nickel steel with vapour-deposited aluminium coating. The slit-viewing microscope allows a 15 mag object to be seen off the slit. A star as faint as 13 mag can be centred very easily on the slit with the light reflected from both the slit jaws. The maximum unvignetted slit length is 10 mm, corresponding to 160 arcsec at *F*/13 focus of the 1-m reflector.



Efficiency of the grating, transmission of filters (1,2,3,4), and the grating angle as a function of wavelength. The observable range of wavelengths is shown for each grating position.



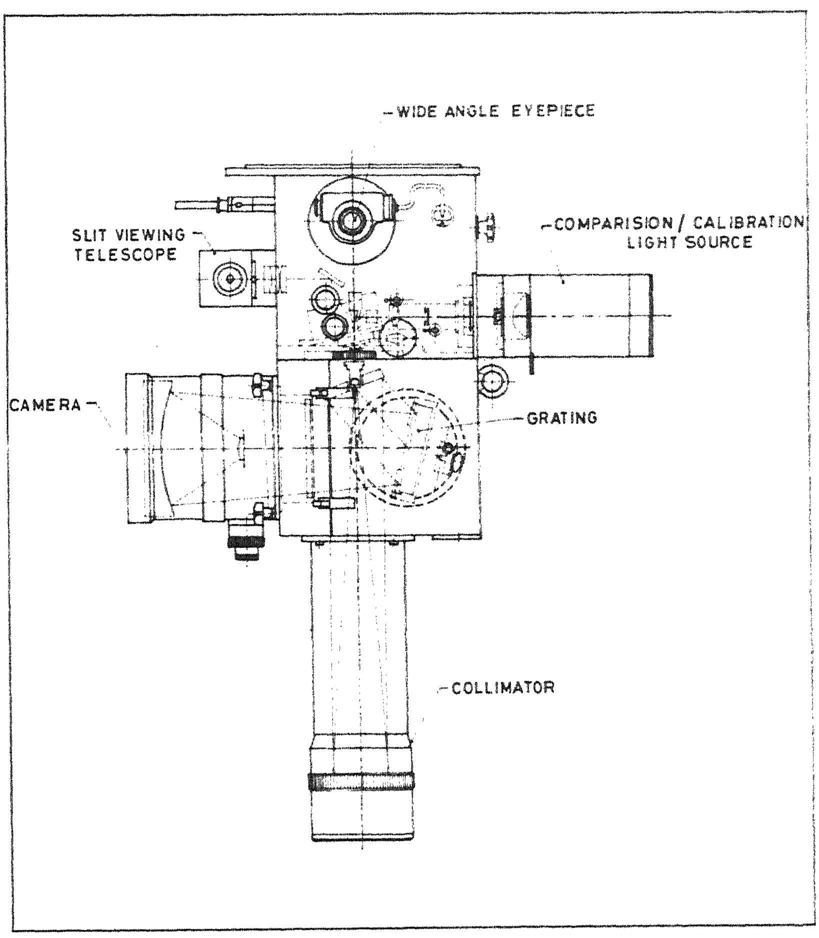
A blue spectrum of Comet Halley obtained with UAGS on March 6. Emulsion: Kodak IIaO, camera: 170 mm, $\alpha = 33°$, dispersion: 86Å mm^{-1}.

Point objects can be trailed along the slit for up to 3 mm, using a rocker prism. The period for one cycle is 30 seconds. The comparison spectrum can be recorded on either side of the spectrum of the object at any separation from 0.2 to 10 mm on the slit. An intensity calibration spectrum can be obtained on a separate plate. To affect this, the wavelength calibration source is replaced by the continuum source and a neutral density stepwedge of transmissivities 0.10, 0.16, 0.25, 0.40, 0.63 and 1.00 inserted in the light path.

A filter wheel following the slit allows a choice of filters for order separation and also for matching the colour of intensity calibration souce with the spectral type of the object. A neutral density filter can be inserted while observing bright stars.

An idea of the exposure times may be illustrated: The recurrent nova T Coronæ Borealis of V=9.8, with a red (secondary) spectral type of M4 requires an exposure time of 90 min in the range of 5000 Å – 7000 Å, at a dispersion of 136 Å mm^{-1} (110 mm camera) and width of 1.5 mm on slit (200 μm projected), on Kodak 098-02 emulsion. Filter 3 was employed and the grating angle was 37°.5.

Modifications are in progress to adapt the existing cameras of 125 – 500 mm focal lengths with Varo single stage image intensifiers at their foci. More gratings are being acquired. It is also planned to provide the spectrograph with an exposure meter in future.



Design of the Universal Astronomical Grating Spectrograph.

Specifications:

Slit:	width	0.01-3.00 mm
	length	0.2-10.0 mm
	broadening	0.0-3.0 mm
	rate	0.03 Hz
Filters:	1.	3440-4550 Å
	2.	3840-5400 Å
	3.	> 4970 Å
	4.	> 5640 Å
	5.	Neutral
	–	Free opening
Grating	grooves	651 mm^{-1}
	blaze angle	5°
	blaze	4000 Å (1st order)
	angle of diffraction*	$\beta = \alpha - 48°$
Camera A:	type	Schmidt
	aperture	125 mm
	focal length	110 mm
	field angle	± 5.5°
	plate format	11.4 × 50.0 mm
	reduction factor	1.5 cos β cos α
Camera B:	type	Schmidt
	aperture	175 mm
	field angle	± 5.5°
	Plate format	11.4 × 50.0 mm
	reduction factor	4.7 cos β cos α
Dispersion	camera A	136 Å mm^{-1} 1st order 3400-7000 Å
	camera B	86 Å mm^{-1}

*The angle of incidence α may be read out directly on the grating mount.

Automated photoelectric spectrum scanner

In his attempt to bring stellar spectroscopy to India, Vainu Bappu began to equip the 20 inch (50 cm) and 15 inch (38 cm) telescopes with spectroscopic accessories built in the laboratories of the Kodaikanal Observatory. One such instrument was the photoelectric spectrum scanner, working in a dc chart recording mode. The basic optical design was of Ebert-Fastie type, however, using two different, identical mirrors for collimator and camera. The grating was rotated using a continuous motor. An alternative, manual rotation was available for discrete operation. The instrument went into regular operation on the 38 cm telescope in 1968.

The scanner was taken to the 1-m telescope when the latter became operational in 1972 at Kavalur. Vainu Bappu replaced the camera and collimator mirrors with a single mirror in 1974, the year when the observatory obtained the 12 bit TDC-12 computer of 4 K memory and 2 μs cycle time, manufactured by the Electronics Corporation of India Ltd. (ECIL). The main function of the computer was instrument control and data acquisition. With the help of the ECIL engineers, the spectrum scanner was automated in 1976 (cf. M. K. V. Bappu 1977 : *Kodaikanal Obs. Bull. Ser. A.* 2, 64-68). The grating was driven by a stepper motor, coupled to the grating through a wormwheel and gear, under the control of the computer. Through the conversational part of the program, the grating could be set to any desired position as read out on a dial gauge coupled to the grating through a lever. A scan of the wavelength comparison source (normally Mercury lamp) helped in obtaining the wavelength scale. With respect to this, one could define a reference channel and scan from any one channel to another sequentially, at desired channel spacing, or alternatively, desired sets of channels in random order and separation. Here, the word 'channel' is used for a given grating position (and hence wavelength), even though the instrument is basically a single channel type. There was provision to obtain a reverse scan also, in which case a compensation could be made for a known amount of backlash. The scans could be continuously repeated and co-added in the memory of the computer, either for a fixed number of scans, or continuously until sufficient signal was built up as judged by the periodic print-out of maximum and minimum counts in the entire data. An oscilloscope display of the spectrum also helped in this decision. The reverse scan was planned to be used in future development where a tilting mirror would, under the computer control, help in moving from star to sky in direct and reverse modes, respectively. The main idea was thus a rapid scan possibility where an individual scan was completed within a few minutes before the sky transparency varied. The normal practice is to choose the counting interval of 50-300 ms for each channel. Available were a maximum of 216 channels each in both directions or 432 in forward direction with no reverse scan.

The automated spectrum scanner was used maximally between 1977 and 1982 in this mode. The computer programme and the data occupied the entire memory and the programme needed to be reloaded whenever there was a change of observing programme. (The data acquisition by conventional photometry and photometric monitoring was automated through another programme.) The programmes

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                INDIAN INSTITUTE OF ASTROPHYSICS.
                    KAVALUR OBSERVATORY.
                AUTOMATED SPECTRUM SCANNER  &
                    PHOTON COUNTING SYSTEM.

    PLEASE TYPE IN:
                  P---FOR PHOTON COUNTING.
                  S---FOR SCANNER.
                  A---FOR OCCULTATION.
                  M---FOR CONTINUOUS PRINT $ TIME.
                  .---FOR PULSAR.
```
['S' was typed in here.]

```
NAME OF OBJECT      =
P.M.T IDENTITY      =

SLIT WIDTH          =

FILTER              =

ADJUST.REF.CHANNEL  =
REF.CHANNEL         =
FIRST CHANNEL       =
LAST CHANNEL        =
MODE                =
CHANNEL SPACING     =
BACK SCAN NEEDED    =
BACKLASH            =
COUNTING INTERVAL   =
NO OF SCAN NEEDED   =
SHALL I START       =
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Start-up procedure with the spectrum scanner programme.

were initially fed using punched paper tape on the slow speed reader of the teletype, but later a magnetic tape unit was acquired. In a few years a need was felt to have a microprocessor control since it would be more compact, reliable and hence relatively maintenance-free. Such a system was fabricated in the laboratories of IIA in 1982.

The new control unit incorporates all the photon counting data acquisition requirements : the spectrum scanner, conventional photometry, continuous photometric monitoring, fast photometry, and a programme that can fold and co-add fast photometric data (particularly suitable for observing optical light curves of pulsars). The system is based on the Intel 8085 8-bit microprocessor board and includes a 16 bit timer, 16 K of ROM, 4 K of RAM, a 24 bit counter, 24 I/O lines, an interrupt controller, an I/O expander with control circuits, two digital to analogue converters, display units to display minimum and maximum counts and number of scans, and a printer. At present, the data are printed out at the end of each scan. It is planned to provide a magnetic tape unit in future.

The spectrum scanner was built in the mechanical shops of the Institute by Alfred Charles using optics made by A. P. Jayarajan. The software and interfacing with TDC-12 was implemented by ECIL, whereas the hardware design, fabrication and software of the current version is due to P. Santhanam.

Specifications :

Collimator-camera :	f—500 mm
Grating :	600 l mm^{-1} 7600 Å blaze
Dispersion :	25 Å mm^{-1} in 1st order
Entrance apertures :	Circular : 800, 1620, 600 μm diameter rectangular : 250 μm × 6 mm, 6 mm × 2 mm
Exit slit :	continuous up to 6 mm (least count : 20 μm)
Resolution : (channel separation)	10 Å in 1st order 5 Å in 2nd order
Maximum no. of channels :	425

historical snippets

Transits of Venus 1761 and 1769

Venus comes closest to the earth at the time of its inferior conjunction, when it is normally lost to sight in the sun's glare. On the rare occasions when it is near the nodes of its orbit at an inferior conjunction the dark body of Venus can be seen to transit across the bright solar disc. Four transits of Venus occur in 243 years, at successive intervals of 8,105½, 8 and 121½ years. The recorded transits are dated 1639 December 4; 1761 June 6; 1769 June 3; 1874 December 9; and 1882 December 6. The next two will occur on 2004 June 8; and 2012 June 6.

Edmund Halley of the comet fame suggested in 1679, after observing the more frequent transit of Mercury*, that transit of Venus can be used to measure solar parallax. But contrary to popular belief, he was not the first one to do so.

In 1663 James Gregory (b. 1639 – d. 1675) in his book *Optica Promota* (where he also described the principle of a reflecting telescope), while discussing the problem of the determination of two planets by observation of their conjunctions, wrote:

> 'The problem has a very beautiful application although perhaps laborious, in observations of Venus or Mercury when they observe a small portion of the Sun; for by means of such observations the parallax of the Sun may be investigated.'

James Gregory notwithstanding, it were Halley's eloquent pleas, backed by his own personality, that made different countries – especially France and England, – sit up and plan transit expeditions to remote parts of the world to observe the transits of Venus.

The aim was to observe the times of the beginning and the end of the transit, from different places. All that was needed was a tèlescope fitted with a micrometer, and a good pendulum clock. It was of course necessary to accurately know the longitude and latitude of the observer. Therefore a quadrant and a sextant were also required.

Rev. William Hirst, sent by the Royal Society, London, observed the 1761 transit from the top of the Governor's house in Madras accompanied by the Governor Lord Pigot, and the Chief Engineer John Call. Hirst, and many others, observed that contrary to expectation, the contact of Venus with the sun was not sharp, Venus appearing to stick to the sun.

The King of France sent Father Guillaume Le Gentil to India to observe the same transit. The seven years war (1756-63) was raging between England and France and Le Gentil's ship had to make wide detours to avoid being attacked by the English. By the time he reached Pondicherry, the transit was over. He decided to wait for the 1769 transit, measuring Pondicherry's longitude in the mean time. He could not observe the 1769 transit because it was cloudy. On his way home, he was shipwrecked twice, and eventually when he reached France after an absence of 11 years he found that he had been declared legally dead and his property distributed among the next-of-kin.

The 1769 transit is a watershed for non-astronomical reasons. In 1768 Captain Cook sailed on his first voyage to Tahiti on an expedition sponsored by the Royal Society in conjunction with the Admiralty. The French Government instructed all its men-of-war to leave the ships of Captain Cook unmolested, because they were out on enterprises that were of service to all mankind.

Captain Cook's secret orders were that after the transit he should search for an imagined continent, Terra Australis, in the southern hemisphere, and to chart islands in the southern seas. Charles Green, a Greenwich assistant was assigned to assist Cook in the astronomical observations. The observational data were analysed in 1771 by the Astronomer Royal Nevil Maskelyne who remarked:

> 'It must be confessed that the results of these observations (most of them were made by Mr. Green) differ more from one another than they ought to do... the cause of which, if not owing to want of care and address in the observer, I do not know how to assign it'.

After the transit, Cook went on his well-known exploration of Australia, and made two more highly successful non-transit voyages. (It should be added that a major factor in Cook's success was the availability of the recent results on the treatment of dreaded scurvy).

The Royal Society had again sought the help of the East India Company for the 1769 transit. The Secretary wrote (22 January 1768): 'The honor of this Nation seems particularly concerned in not yielding the palm to their Neighbours, and the Royal Society intends to exert all its strength and influence in order to have this observation made...'.

Both the neighbourly palms were left high and dry because of the cloudy skies over Madras and Pondicherry.

Many telescopes and other instruments sent from England for the 1769 transit were eventually collected and used at the Madras observatory when it was taken over by the East India Company.

In retrospect, of all the methods of determining solar parralax, the observations of the transits of Venus raised the highest hopes, involved the largest expenditure of energy and resources, and proved the greatest failure.

The reason was the following:

The assumption underlying the method was that the times of the beginning and ending of the transit could be observed accurately. This assumption turned out to be wrong; the dark Venus and the bright sun appeared to cling together, and it was not possible to say with confidence when the transit began or ended – a phenomenon known as 'black drop', caused by the illuminated atmosphere of the planet. The 1769 transit gave a value of the solar distance that was off by several million miles; the 1874 results were uncertain by about 1½ million miles. The 1882 value was better (92½ million miles), but the scatter was very large.

Even if the transits of Venus did not quite live up to their promise, the 1761 transit did procedure an important result: Mikhail Vasilyevich Lomonosov showed that Venus, like earth, has an atmosphere.

R. K. Kochhar

In order to observe the transit, Halley persuaded the East India Company to take him free to the island of St. Helena, since King Charles II could not fiinance the trip. – *Ed.*

of human elements

A physical argument

Here his [Tycho's] fiery nature led him into an absurd though somewhat dangerous adventure. A quarrel at some feast, on a mathematical point, with a countryman, Manderupius, led to the fixing of a duel, and it was fought with swords at 7 p.m. at the end of December, when, if there was any light at all, it must have been of a flickering and unsatisfactory nature. The result of this insane performance was that Tycho got his nose cut clean off.

He managed however to construct an artificial one, some say of gold and silver, some say of putty and brass; but whatever it was made of there is no doubt that he wore it for the rest of his life, and it is a most famous feature. It excited generally far more interest than his astronomical researches. It is said, moreover, to have very fairly resembled the original, but whether this remark was made by a friend or by an enemy I cannot say. One account says that he used to carry about with him a box of cement to apply whenever his nose came off, which it periodically did.

Oliver Lodge in 'Pioneers of Science'

Dover, New York, 1960

out of context

A reasonable account of all of the above observations can be given by assuming: (1) that the Sun is a typical star of 1 solar mass.

A. Rev. Astr. Ap. (1970) 8, 326.

**

Using the completely insufficient evidence so far available one may reach the conclusion that there are thus two kinds of pulsars.

Ap. Lett. (1970) 8, 195.

**

The binary WR stars have certainly all undergone mass exchange according to the original suggestion of Paczynski (1967).

IAU Symp. 49, D. Reidel, Dordrecht, p. 229.

**

Smyth proceeded to subtract the 26° 17' angle .... from the Pyramid's latitude of 30° ... and obtained an angle of 3° 43'.

Secrets of the Great Pyramid, Penguin Books, p.86.

**

The Indian Institute of Astrophysics traces its history back to the year 1786 when William Petrie set up a private observatory at Madras. To mark the completion of 200 years of its existence, IIA is holding a one-day symposium on "*200 years of Astronomy and Astrophysics*" on 5 December 1986. This date marks the bicentennial of the first recorded observations made by the observatory. IIA has invited the Astronomical Society of India to hold its 11th meeting at Bangalore, from 8-10 December 1986.

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