Number 2 January 1990

WISH YOU A HAPPY NEW YEAR

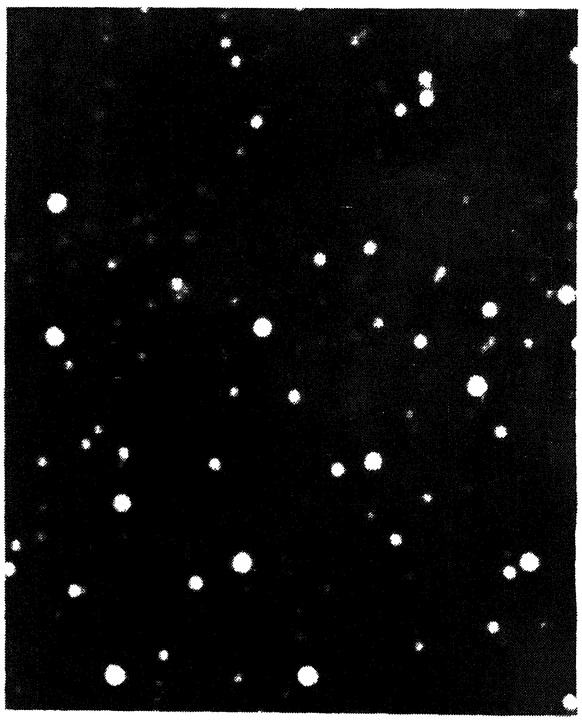
A flower from the Magnolia Mutabilis, a delicate, very slow growing, small tree of 3 to 4 meters high. The foliage is very pretty consisting of broad dark green, shining leaves and the flower is cream coloured with a sweet fragrance. You can find this tree near the Administrative block at Bangalore. -Photograph by M. Vyas.

The beautiful gardens at IIA, Bangalore, Kavalur and Kodaikanal stand testimony to Dr. Bappu's love for trees and plants. He took special care in the layout of the gardens and planted various species of flowering and fruit bearing trees, some of them rare and exotic. From this issue onwards we shall endeavour to publish a snapshot from our garden with a brief description of the species. This column will be contributed by A. Vagiswari

CCD IN SCAN MODE

For imaging a large area of the sky using CCD as a detector, the scan mode with drive off has certain distinct advantages. This technique was developed with an IBM-PC/AT as the controller. In conventional mode (stare mode) the telescope tracking is on and the image is kept stationary on the CCD surface. In the scan mode, the charges created in the CCD by the image is shifted in synchronism with its movement across the detector. The data acquired is stored as a file in the PC and later transferred to magnetic tapes for image processing and analysis.

Binning of rows and columns was employed to match the image scale to the row shift timing of the controller. With the VBT, a 2 x 2 binning gives us a row shifting timing of 40 milliseconds. Initially we faced the problem of image elongation along the rows which was traced to the malfunctioning of the serial row binning electronics. However, we found serial 3 binning works well with our controller and so the control program was accordingly modified to work with



a 3 x 3 binning. This essentially degrades the image to the equivalent 2 arc second seeing images. The figure above shows a typical frame of the image acquired in the scan mode. The effective exposure time is 24 seconds. The limiting magnitude is about 20.5.

R. Rajamohan and R. Srinivasan

THE DRIVE SYSTEM OF THE VBT

Design

The basic drive system, electronics installation and checking was carried out during August-October 1985. The multiloop feedback control system was designed and installed by Bhabha Atomic Research Centre, Reactor Control Division. The following were the members of the team.

1. S.N. Seshadri.* 2. B.N. Karkera. 3. S.R. Kundgolkar. 4. C.K. Pithawa. 5. S.S. Kane.

V. Chinnappan (IIA) was associated with them. He also designed and installed the microprocessor based display and drive system. P. Santhanam and R. Srinivasan designed and installed the auxiliary drives. We attempt to record the various salient features and important observations made during the installation.

The drive system employs DC torque motors. It is driven by DC power amplifiers. These motors are pan cake type with permanent (ceramic) magnet stator and wound rotor. The stator and rotor are in annular ring form. The inertia of the motor is much less than conventional DC motor. So it is possible to accelerate or decelerate the motor at a very fast rate. The mechanical time constant of the motor is about 10 milliseconds. The drive system consists of multiloop feedback control system and the power drive. There are basically four types of feedback. 1. Current feedback from power amplifiers. 2. Velocity feedback from tachogenerators. 3. Position feedback from incremental encoders. 4. Position feedback from absolute encoders.

During commissioning of the drive system, instead of closing all the loops at the same time, it was carried out loop by loop starting from current loop. First the telescope was reasonably balanced. Then the motor was driven by applying input to the power amplifier.

A variable DC (0 to 10V) supply was given as input to the power amplifier and motor was driven by the power amplifier. 28V DC supply was given to power amplifier. The current taken by the motor in all directions is noted. As the current indicates the load on the motor, uneven current taken by motor indicates the amount of unbalance in the telescope. In each axis of telescope there are two motors. One is used as a drive motor and the other one as a counter torque motor. For determining balance only one motor was operated. The servo system has a switch by which either the drive can work with one motor or two motors in the counter torque mode. The offset in the power amplifiers were adjusted by grounding the input to the power amplifier and adjusting the offset potentiometers for small output using a rheostat as a dummy load. Then the current loop is closed. The main purpose of current loop is to keep the torque of the motor adequate for varying loads. The input to current loop is compared with the signal generated by drop of motor current sensed through a low value series resistance. The difference in signal is amplified and is used to drive the motor. Since two motors are there in each axis, the sharing of current between drive motor and counter torque motor is adjustable in this loop.

Next the speed loop is closed. The tacho generators which are also of pan cake type ceramic magnet field stator and wound rotor like the telescope drive motors, are mounted in the same shaft in which drive motor is mounted. The commutator and brushes are designed for long life. The tacho output is first level shifted so as to match the reference.

From October 1985 to June 1986, the telescope was working in speed loop. A handset was made which gives different voltage levels required for slow, set, guide, fine guide and tracking speeds.

Photographs were taken from January to June 1986 using prime focus photographic camera. In July 1986, position loop was closed. The sidereal clock output (100 KHz) is divided by BCD rate generators to produce suitable pulse rate for different speeds. When the telescope starts moving, the incremental encoder which is mounted in the bull gear step cut out, driven by friction wheel, gives one pulse for 0.18 arc second of telescope movement. The friction wheel is pressed against the bull gear face by a preloaded spring, so that it makes positive contact at all positions of the telescope. The position error is generated in a 16 bit binary Up/Down counter. The sidereal rate is given to Up counter. The incremental pulses count it down. The resultant count is the instantaneous error. The error is given to 16 bit bipolar Digital to analogue Converter which generates an error in $\pm$ 10V range. The position loop signal is first given to a compensation card. Here an active RC network can tune the system for good stability. The output of this card is suitably amplified to serve as an input to the speed loop. The output of speed loop is used as input to the current loop. The error generated by current loop drives the motors through the power amplifiers.

Performance

In a complex servo system like this major part of the work gets completed fast. To achieve the remaining part is indeed the most time consuming, frustrating, difficult and most demanding task.

As mentioned earlier the speed loop was closed as early as September 1985. This amounts to about 80% of work. When the position loop was closed in June 1986, it was found that the earlier system parameters set were not adequate. Error voltage generated by position loop was low. Also the speed range to be covered is 3600:1. So, for the same set of gain values, the system goes to saturation in high speeds and not adequate in low speeds. It was therefore decided to bifurcate the gain into two ranges. High gain for low speeds and usual gain for high speeds. The gain has to be selected automatically according to the speed selected. This scheme improved the position loop performance.

R. Srinivasan, Head, Electronics & Computer Centres
Cannot stand noise

During the time of long exposures, it was found that the declination axis makes random movements of the order of 3 to 4 arc seconds. Later it was traced to the noise pick up in the wiring. The control signals travel some distance from console panel to relay panel. Being a low level signal, small pick up in the route caused the trouble. The corresponding relays were removed from relay panel and mounted in the cards in console itself. Also all inputs are grounded when no switches are pressed, thus eliminating the possibility of noise being picked up by open inputs of operational amplifiers.

During normal operation, it was found that the system misbehaved, i.e. under stationary conditions it was trying to move without any command for movement. This was traced to the break in the feedback path in the incremental encoder. The declination incremental encoder was not making proper contact with its friction wheel. When it makes good contact in east, it fails to make good contact in the west side. It was found to be caused by jammed bearings which did not allow the bracket holding the incremental encoder to be pressed always against the bull gear face.

One of the incremental encoders was occasionally misbehaving. The incremental encoder is expected to give pulses only in one channel for clockwise rotation and should give pulses in the other channel for anticlockwise rotation. At no time should it give pulses in both channels for rotation in a particular direction. This was traced to improper threshold adjustment in the encoder which was corrected. One of the incremental encoders behaved erroneously and was subsequently replaced by a new encoder.

After a year's use the polar axis tacho generator developed some short circuit in its rotor winding. This has resulted in a square wave kind of voltage instead of sinusoidal waveform causing small shift in image positions. The tacho generator was replaced by a new one. There are three feedback loops in the drive system, the current, speed and position loop. Whenever there is a break in the feedback path (due to component failure, disconnection in the connector or wire or contact problems in printed circuit cards) the system fails to get feed back signal causing runaway condition. A protection circuit was developed and incorporated in the interlock circuits to identify and switch OFF the power during such failures.

Some of the remote sensing power supplies produced large ripples. It was found that the remote sensing wire has picked up noise enroute and was amplified by the power supply. In a few cases, the remote sensing was replaced by local sensing and when possible power supplies were mounted near to load points. High ripple in the power supply has corrupted the data output from absolute encoders. Local filtering was introduced to reduce the ripple to acceptable level.

The drive system has been functioning perfectly since the time the Research Advisory Committee headed by Professor B. V. Sreekantan visited the Observatory on March 4, 1988. Of course, during the last three years we faced as much noise from the observers as the drive system faced from the circuits! Now there is peace, thanks to the stable performance of the telescope at all speeds.

V. Chinnappan and R. Srinivasan

(*Late Sekharipuram Narayana Iyer Seshadri of BARC, was responsible for the design, fabrication and commissioning of the Control System of the VBT. He passed away on February 2, 1986, at an early age of 49 -eds.)

CASSEGRAIN SYSTEM

Optical Quality

Interferometric test data and prime focus CCD images with and without Wynne corrector have shown that the primary mirror is capable of producing images of $\simeq$1.2 arc sec. and FWHM in the range 0.7 to 0.9 arc sec.

In order to retain this image quality at the cassegrain focus, the cassegrain secondary mirror (convex hyperboloid) needs to have a figure better than $\lambda/4$ and on axis alignment of secondary mirror in terms of centering and tilt should be better than $\pm$ 125 μ and $\pm$ 15 arc sec. respectively.

Installation of secondary was over in the first week of November 1989. Final alignment was done during 7-9 November 1989. Fortunately the seeing on 7 November was reasonably good ($\simeq$ 1.5 sec. of arc). Visual observation of double and single stars at the cassegrain focus indicate cassegrain image quality better than 1.5 arcsec. FWHM may be expected to be 0.9 to 1.1 arcsec. These estimates are seeing limited.

1-1.5 mm of shift and 0.5 to 0.7 minute of tilt variation in secondary alignment are seen in different orientations of telescope due to inherent flexing and differential response of serrurier trusses. This produces a change in intensity distribution of the stellar images and images look non-circular when one moves away from the best aligned position of the secondary.

It was found later that the radial supports of the primary mirror was not working and due to more load on the defining radial supports, the non-circular images were appearing. The radial supports were readjusted to improve the image quality. Best seeing limited images have been obtained.

Optical Data

Primary Mirror:

1.	Diameter of the blank	2360 mm
2.	Material	Zerodur
3.	Density	2.52g/cm^3
4.	Weight of the blank	4.134 tons
5.	Weight of the mirror	3.55 tons
6.	Edge thickness	375 mm
7.	Central thickness	330.5 mm
8.	Clear aperture of the mirror	2320 mm
9.	Edge bevelling	28 mm (projected 20 mm)
10.	Cassegrain hole diameter	720 mm
11.	Central obscuration	0.3

Prime focus

1.	F-ratio	3.23
2.	Focal length (mm)	7510 $\pm$ 0.001%
3.	Radius of curvature (mm)	15020 $\pm$ 0.003%
4.	Conic constant	-1

5.	Image scale	27.476 sec/mm
6.	Wynne corrected field	± 20 min

Cassegrain focus

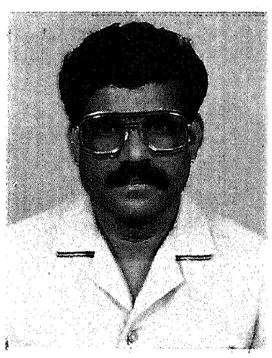
1.	F-ratio of cassegrain system	13
2.	Diameter of the mirror	660 mm
3.	Clear aperture of the secondary	630 mm
4.	Conic constant	–2.7776
5.	Back focal distance from primary mirror vertex (mean)	1493 mm
6.	Back focal distance from cell	708 mm
7.	Secondary movement available	+40 to -40 mm
8.	Corresponding back focal distance from mirror vertex	880 to 2184 mm
9.	Image scale	6.869 secs./mm

A.K. Saxena

Focus Motor Control Sytem

The drive system for focus motor was designed in our Electronics Laboratory. The system has been installed and is working satisfactorily.

The drive system is a four quadrant DC drive. DC servomotor (Model TT 2922 of Inland Motor Co.) has been used to provide precise motion of the drum assembly, which holds the secondary mirror. A peak torque of 24 Newton Meters gives ample power for fast and accurate positioning of the drum. Speed less than one RPM is achieved without cogging.



V. Chinnappan, Sr. Computer Engineer
Long Distance runner —until marriage

The closed loop control system consists of the speed and current loop. A tacho generator which is directly coupled to the motor shaft provides the velocity feedback. This voltage is compared with the reference voltage. The error thus generated is given as reference to the current loop. Current feedback which indicates the torque requirement is thus compared. The output of current loop is given to a DC power amplifier of 12200 W capacity. The power amplifier drives the motor. The power amplifier current can be limited by a suitable resistor value, thus limiting the torque generated by the motor.

The motor speed can be selected both for forward and reverse movement of the cassegrain focus assembly over a speed range of 10 micron/second to 500 micron/second. The linear traverse range covers 80 mm span from end to end. The operational handset at cassegrain end is used for control. Similar operational switches are available in the console room.

Safety features include power-off/brake-on action to hold the focus position under power failures. Limit switches are provided both at the top and bottom traverse ends which cut off motion in the unsafe direction.

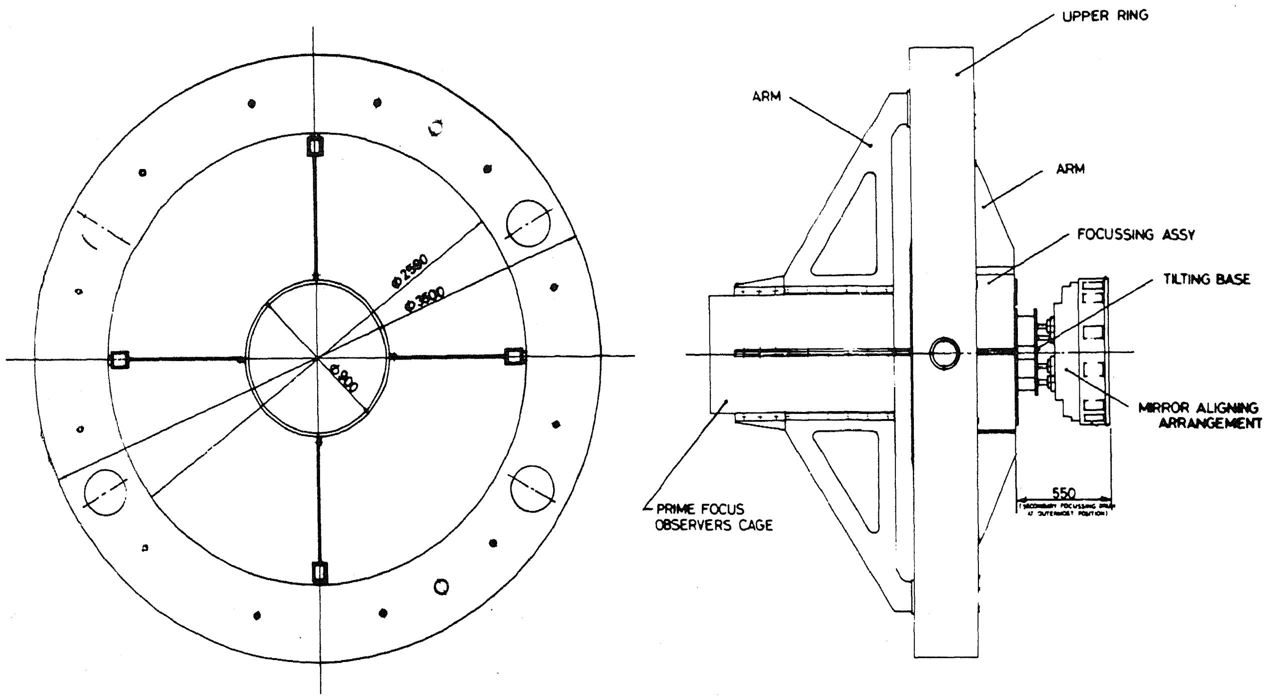
It is found that we are able to move the focus drum in incremental motions of 5 microns and accurately stop without overshoot. The speed is maintained constant in all orientations of the telescope both forward and reverse directions. It is possible to accurately focus the telescope within a few minutes. The same assembly is used for prime focus instruments, thus eliminating the frustration of manual mode focusing which was available earlier.

V. Chinnappan and R. Srinivasan

Mechanical Details

The overall view of the mechanical assembly is shown in the figure (p. 6). On the cylindrical surface four machined faces at 90° to each other have been provided. The machined faces which are parallel to the axis of movement of the cylinder are made parallel to optical axis of the telescope during assembly. On the four machined faces at the side of the drum, eight numbers of Thomson Pillow Blocks Ball Bushing are fitted. The bore of these ball bushing have a smooth alignment over four member of guide rods parellel to each other on the outer shell. As per the original design the power for focus movement is provided by DC Servo motor through a saginaw ball screw/nut assembly which is located parallel to the optic axis but placed eccentric within the annular space between the drum and the shell.

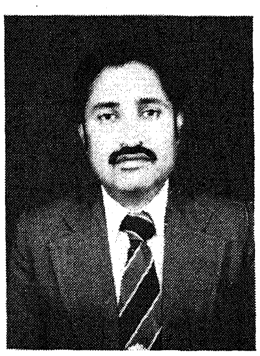
The entire focus assembly weighing about 1000 kg is located with respect to the optic axis by means of 6 mm thick fins. The load is equally distributed onto the 2.6. metre internal dia upper ring and has provision for preloading the entire system using fork and nut assembly. A linear transducer placed in the annular space between the moving drum and stationary shell and connected to the moving drum has facility to display the focus position within one micron. For using



Secondary Focusing Assembly

the prime focus one has to dismount the secondary mirror cell assembly with the alignment unit along with the spacer using ten tonne capacity dome crane. This can be stored in a special box at the observing floor.

During the trial operations after focus assembly was assembled in the telescope, it was observed that the load on the DC Servo motor was very high and the motor was drawing very high current which dissipated heat



B.R. Madhava Rao, Sr. Mechanical Engineer
Leg Spinner while in college

around the tube axis. It was also observed that in view of the use of very smooth saginaw ball screw/nut assembly, which has practically zero holding torque, the entire holding torque had to be provided by the E.M. brake and DC motor. Since the total moving weight was of the order of 1000 kg the entire load used to slip down by 7 mm before the brake holds the system.

It was therefore decided to introduce a worm reduction gear box between the DC motor and the saginaw screw to bring down the speed considerably. One number 70:1 worm reduction gear box 0.25 HP capacity was selected and bought from M/s. Elecon Engineering Company. Being a worm reduction gear box the input and output shafts were located at 90° to each other.

The 70:1 worm reduction gear box was mounted on top of the shell using specially designed adoptors in view of space constraints. This also led to some modification of the prime focus observing cage.

After the worm reduction gear box was introduced the movement of focus assembly is very smooth and can be controlled within 10 microns. There is totally no slip of the focus drum and the starting and running current is very low compared to the earlier values, when no gear reduction was used.

B.R. Madhava Rao

CCD 2000 IMAGING SYSTEM

In our Astromed CCD 2000 Imaging System, the CCD chip (GEC-P8603A) failed in October 1989, while in use with the one meter telescope at VBO, Kavalur. It was noticed that a stain had developed over the chip surface and one lead had broken . A new lead was bonded using ultrasonic technique at Bharat Electronics Limited, Bangalore. Subsequently a test was carried out in our Electronics Laboratory for the functioning of the detector, which revealed that the chip had failed permanently. The device along with the Liquid Nitrogen Dewar housing will be taken for repair and retesting to Astromed Limited, Cambridge,United Kingdom, during January first week, 1990. The system is expected to be available for use with the VBT during the last week of January 1990. Meanwhile, we acknowledge the cooperation of the TIFR scientists for sparing their CCD camera for use at the VBT. Our PC/AT based CCD controller has been interfaced to the TIFR CCD Camera and is working satisfactorily.

R. Srinivasan and G. Srinivasalu

SPECTROSCOPY AT CASSEGRAIN FOCUS OF VBT

The regular operation of cassegrain focus at VBT has started from the beginning of December. The first instrument to be mounted at this focus is the Boller and Chivens spectrograph with CCD.

The field viewing is done by a microchannel plate coupled CCD system which images the spectrograph slit and the reflected field from the slit jaws onto the monitor in the control room. Guiding and acquisition of the object is done from the control room. Presently the spectrograph is provided with a 20-inch and a 7-inch camera on which a CCD dewar could be mounted. A better camera system is needed to match properly with the spectrograph.

The first stellar spectrum obtained on 5th December through clouds is that of the GO Ia supergiant HR 8752 in the H region. The spectrum shows the Hα as a central absorption flanked by emission on both sides and [NII] lines.

Bappu's favourite object Gamma Velorum was also observed on the same night through clouds. These spectra were obtained with a 1200 line grating and the 20-inch camera giving a dispersion of 15 A/mm. Further improvements are being made to the spectrograph system.

N.K. Rao, F. Gabriel, M.J. Rozario

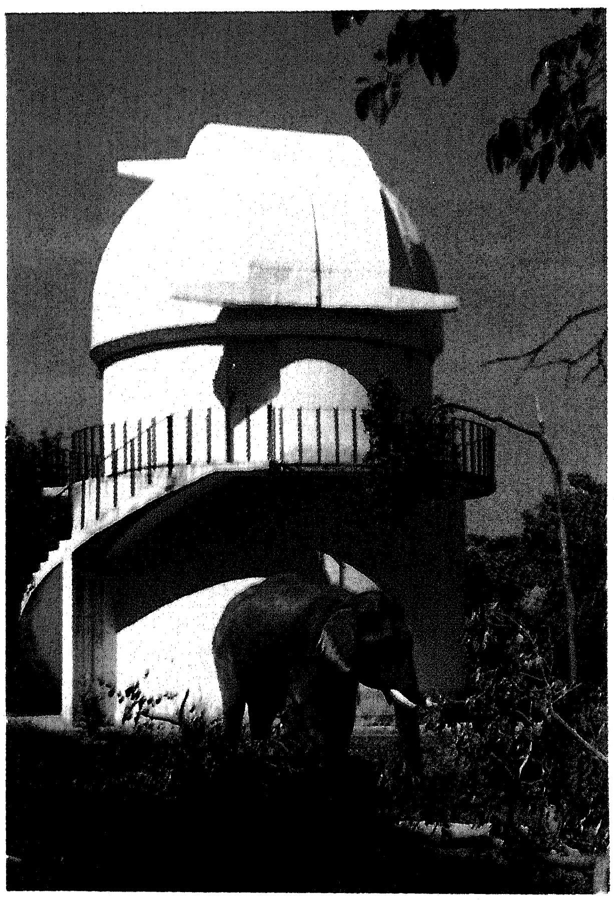
IN DEFENCE OF THE WHITE ELEPHANTS (DOMES)

While we were preparing to welcome the delegates of the First VBT Workshop, fourteen elephants were also present at the campus (to receive the guests!). These elephants became a cause of anxiety to us, as all the fourteen were wild elephants!

Jawadi hills (in North Arcot District, Tamilnadu) where Kavalur is situated is not known to have elephants before, as it is a semi arid place. However, a year ago a herd of elephants from neighbouring Andhra Pradesh and Mysore forests sneaked into Elagiri hills and from there to the Jawadi hills. In the beginning they would occasionally visit the Observatory campus

It is time for celebration - The first spectrum has been obtained.

and go back. The 100 acre land of the Observatory is fenced, hence no cattle can graze inside the campus. This has seen the growth of luscious grass. Also, the Observatory has an ample water supply, which takes care of its gardens, the cooling towers and the lotus pond. The green grass and fresh water may have attracted the elephants into the campus.



The 45cm Schmidt- *an additional tusk to blink*

To avoid any untoward incident on the day of the VBT Workshop, a decision was taken to chase away the Jumbos. The forest department was contacted for this task, which was kind enough to send **Basha, Pallavan** and **Bharati** headed by **Kaleem**. Kaleem, Basha, Pallavan and Bharati are none other than forest department's trained elephants. These four elephants were inside the campus, roaming around, so that when they encountered the wild ones, they could chase them away. It was later found that the team headed by Kaleem was no match to the fourteen wild ones. The herd, went on a rampage as if to show their dislike towards our hostility. They broke the water pipe lines, the cooling water tank, destroyed the bamboo bushes, some mango trees and banana plants near the staff quarters. For each visit to the campus they broke a dozen fence posts. Occasionally they even went to the staff quarters, to say 'Hello' to the housewives.

There was panic when they started their mischievous behaviour and continued to stay inside the campus. The district forest officer was contacted and requested to inform the wild life warden to send two more trained elephants, **Dev** and **Pandian** to reinforce the strength of Kaleem. Meantime crackers were used to threaten the wild elephants and this helped to some extent. On hearing the sound of the crackers the elephants decamped but to come back the next day. Again the crackers were burst and they left realising that we human's were no longer hospitable. As a preventive measure it was decided that we should have an electrical fencing along the boundary which would give a severe shock but would not be fatal to animals or human beings.

R. Sivashanmugham

VAINU BAPPU OBSERVATORY

Sky Condition at Kavalur September -November 1989.

	Spectroscopic hours	Photometric hours
September	34	3
October	111	12.5
November	126.5	40.5

SECOND VBT WORKSHOP

The second VBT Workshop on "Low Light Level Astronomy" will be held during the second week of April 1990 at the VBO, Kavalur. This workshop will concentrate on technical, scientific and infrastructure problems related to the VBT as a national facility. Participation in the workshop is by invitation as accommodation at VBO is limited. Young astronomers, especially from Universities who are interested in participating in the workshop should write to "The Director, Indian Institute of Astrophysics, Bangalore-560 034".

Editor R.Rajamohan, Editorial Assistant S. Rajasekaran
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