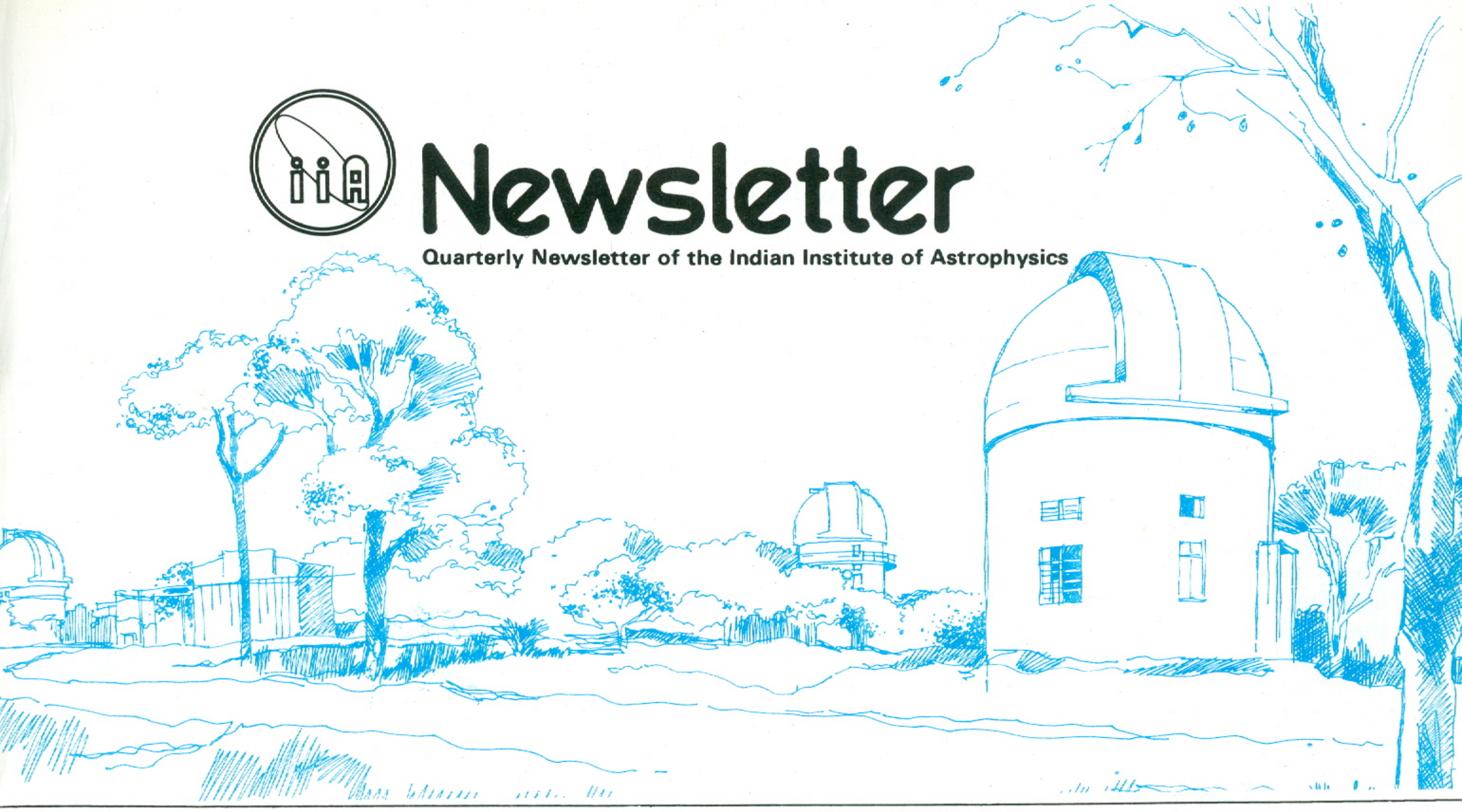
Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics



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Solar Astronomy from South Pole

Jagdev Singh & K. R. Sivaraman

1. Introduction

Continuous monitoring of the sun can pay dividends in finding answers to many problems such as helioseismology, evolution of solar activity and properties of the supergranulation. In principle, one can avoid the interruptions of the day-night cycle by setting up a worldwide network of observing stations. Such an effort was made during the International Geophysical year (July 1957, through December 1958). Since the contributions were from different observatories, the data quality was uneven and there were frequent gaps.

At first sight, observing from space appears to be a possibility. Although this vantage point provides great benefit, the problem of the 24-hour day-night cycle is replaced by a 90-minute cycle for most of the near-earth orbits. Continuous viewing of the sun is possible only from highly inclined orbits. Such a path, however, requires a more powerful booster rocket than that needed for more equatorial orbits, and has not yet been used for solar astronomy. Therefore, to avoid the sunset without leaving the surface of the earth is the travel poleward to the Arctic or Antartic circles during local summer. At such places one can see the midnight sun and make observations without interruptions, weather permitting. The first observations of this kind were made in 1966 from Thule, Greenland using a 15-cm refractor equipped with Hα filter and a 35-mm movie camera that recorded a nearly continuous sequence of photographs over a 62-hour interval.

The study of the oscillations on the solar surface (Helioseismology) is a powerful indirect method to know about the structure and the motions in the sun's interior. It is important to determine the exact frequencies of the oscillations because these frequencies depend on the physical nature of the solar interior and to obtain a good frequency resolution one requires continuous observations for a sufficiently long period of time. The desired frequency resolution of a few millionths of a hertz demands uninterrupted observations over several days. The gap in the data introduces noise and distortion in the derived frequencies. To plan for such an experiment one needs to evaluate the site for such observations in advance.

Another programme which needs long hours of continuous observations of the sun is the study of the birth, evolution and decay of supergranulation. These convection cells on the sun have dimensions of nearly 25000 km and a lifetime of around 20 hours. Therefore, to study the evolution of supergranulation cells one needs data without interruption at least for 2–3 days. The study of the evolution and decay and preferred location of formation of these cells is vital in understanding their dynamics. It is the latter programme of observations that has been planned by the astronomy team for the ninth Indian expedition to Antartica. It is proposed to set up a telescope and obtain the images of the sun continously in the ionized calcium K line at λ 3934 Å using a very narrow band interference filter. Such images (filtergrams) show these convective cells well. The continuous monitoring of the sun will also help to study active plages and their correlation with the magnetic structures. One may even capture quite a few solar flares during this period. If so, one will be able to study the effect of these flares on the ozone layer. The data on ozone layer at Antartica will be collected by the team from NPL, New Delhi.

2. Instrument and Observations

The solar telescope has been specially designed and built in the laboratories of the Indian Institute of Astrophysics, Bangalore. It consists of a heliostat with a 15-cm mirror installed on a pillar 2-m tall. It collects the light from the Sun and diverts in the direction parallel to the rotation axis of the earth. The heliostat is rotated (24 hours per rotation) by a synchronous motor through a worm-wheel arrangement. A second flat mirror at the bottom of the heliostat tube makes the light beam horizontal and feeds an objective of 10 cm aperture and 300 cm focal length. The second mirror has a push-pull arrangement to position and centre the image onto the camera. The converging beam from the objective passes through a broad-band blue filter placed in front of the calcium K line filter. This would avoid heating of the latter. The calcium K filter is the 'Day star filter' with a passband of 1.5 Å centred around the K line and is mounted on a Minolta X-700 camera. This camera has the additional facility to record automatically the epoch of every exposure on a corner of each frame of the filtergram. We propose to obtain the filtergrams once every 5 minutes on 2415 Kodak 35 mm film.

3. Location and Environment

Dakshin Gangotri is a permanent Indian station in Antarctica located at a latitude 70°05′S and longitude 12°00′E. The station is close to the sea coast in summer. About 80 km away and closer to the south pole another permanent station has been established called Maitree. In summer season ice melts at this place and so one can use the rocky surface to install equipment for experiments. The latitude and longitude of Maitree are 70°45′39″S and 11°44′49″E respectively. The solar telescope will be installed at the Maitree station.

Antarctica is the coldest and windiest continent on the earth and the home of blizzards. The special need for extended continuous observations forces one to travel to Antarctica even though the weather conditions are very hostile. The maximum recorded temperature at Maitree station is + 6.3 °C and the wind speed could be as high as 104 km hr.

The ship for the ninth Antarctica expedition left Goa on 1989 November 29 and has reached near Dakshin Gangotri station. The scientists from various organizations will be conducting different experiments; *e.g.* NPL is planning to monitor the ozone layer, University of Delhi is planning to study the growth and productivity of rats and rabbits at Antarctica, DRDO plans to grow the vegetable in green houses, CSI plans to continue the survey programme of the continent. The experiments in meteorology, upper atmospheric conditions and geomagnetism are also planned during this expedition. This is the first time that the Indian programme for the Antarctica expedition has an astronomy experiment. The team consists of three astronomers: Dr. Jagdev Singh, Dr. G. S. D. Babu (both of the Indian Institute of Astrophysics, Bangalore) and Mr. Wahabuddin of Uttar Pradesh State Observatory, Nainital.

National Large Telescope Workshops: Scientific Requirements and Requirement of Site

A proposal for a national 7-m telescope was recently submitted along with the 8th Five-Year plan proposal of IIA. This proposal was discussed at the National Meeting on Astronomy Facilities for the 8th Five Year Plan, organized by the DST at IIA, Bangalore in 1989 August. Most of the astronomers who attended the meeting favoured the proposal and recommended setting up of a most modern large-sized optical telescope in the best possible site in India before 2000 AD as a national facility. In order to discuss the requirements of site for the design and fabrication feasibility of a national large optical telescope it was suggested to hold three technical workshops in 1989 October and December.

The first in this series on 'National Large Telescope: Scientific Requirements' was held on 1989 October 19 and 20 and the second 'Requirement of Site' on 1989 October 21. About 50 scientists from various astronomical institutes and universities attended these workshops held at IIA, Bangalore.

'Scientific Requirements' workshop included 17 talks covering topics on the galactic, extragalactic and observational cosmological problems that can be attempted with a large telescope. The presentations were followed by discussions and critical remarks. The afternoon of October 20 was devoted to general discussion. All the participants emphasized the need for a National Large Telescope.

'Requirement of Site' workshop included 10 talks covering various aspects of selecting a good site for optical and IR Astronomy, including solar astronomy. There were also presentations on the techniques, methods and procedures for assessing the site requirements. The presentations were followed by discussions and critical remarks. The workshop ended with a general discussion.

M. Parthasarathy

Report on the National Meeting on Astronomy Facilities for the Eighth Five Year Plan

A meeting at the national level organized by DST to examine in great detail the scientific proposals submitted by various research groups in the country for setting up major facilities as well as for augmenting the existing facilities for research in Astronomy and Astrophysics was hosted by the Indian Institute of Astrophysics, Bangalore on August 24 and 25. There were 66 participants representing the astronomical community (from the leading research centres in Astronomy, Universities, ISRO and BARC) covering the widest spectral coverage possible namely γ ray, X ray, ultraviolet and optical, infrared and Radio astronomies as well as instrumentation experts from CSIO. In addition, there were the representatives from the funding agencies like DST, Planning Commission and the UGC. A committee of special invitees was given the responsibility to make the final recommendations on the projects to be funded during the 8th plan period in the order of priorities. This committee consisted of B. V. Sreekantan, R. R. Daniel, S. Ramaseshan, K. Kasturirangan, and P. J. Lavakare.

The 27 oral presentations were organized under six areas with an area Chairman for each. These were:

National facilities for optical and IR astronomy (B. V. Sreekantan); National facilities for solar astronomy (K. R. Sivaraman); National facilities for Radio astronomy (G. Swarup); Astronomy facilities in the university system (J. V. Narlikar); Facilities for Instrumentation and Technical Manpower Development (S. Ramaseshan) and Special areas of Astronomy and Special techniques (K. Kasturirangan).

Following this, the area Chairmen presented a summary of the requirements with recommendations wherever possible. Finally, the requirements were consolidated and the priorities discussed further in a joint meeting of the area Chairmen and the committee of special invitees. There was consensus on the projects to be supported in the 8th plan: the main emphasis was laid in completing the major projects which are on hand continuing from the 7th plan like the GMRT, the Focal plane instrumentation for the VBT, furbishment of the Jappal-Rangapur telescope and providing this telescope with upto-date focal plane instrumentation. Regarding the new National projects to be considered for funding during the 8th plan, the consensus was to support the Giant Optical Telescope, the National Solar Vacuum Telescope, and the Instrumentation centre. Special emphasis was laid on funding for the development of scientific manpower at selected universities which are recommended to be equipped with facilities for research in observational astronomy. The final recommendations would be framed by the committee of the special invitees and submitted to the Planning Commission.

K. R. Sivaraman

from the director

As we are approaching the date for starting the eighth five year plan, our minds are full of immense possibilities of taking our astronomers to the forefront of astrophysics during the course of the next decade. There have been three national workshops over the past one year, where plans for development in this field were discussed. In the last of these meetings in Bangalore the astronomical community could zero down to a few selected projects, which need to be given high priorities for implementation during the next decade. It was opined that major thrust is needed in completing projects already begun, and updating completed facilities. Special emphasis was placed on generating scientific manpower by equipping a number of universities with observing equipment. Besides these, an ambitious plan of building two new observational facilities, a modern vacuum solar telescope and a really large aperture optical telescope was mooted. It was realized that the last mentioned item will involve considerable homework before plunging into the project, a process which has been launched without delay. The present issue contains some details of these efforts.

In the first week of December, the Institute hosted the IAU Symposium #142 on *Basic Plasma Processes in the Sun.* More than one hundred and fifty scientists, including 80 scientists from abroad attended the symposium. Many topics on the subject were discussed which covered observational and theoretical aspects of the solar plasma processes.

The Director General of the Council of Scientific and Industrial Research had instituted an annual lecture series in a few cities in India by distinguished scientists. For the last two years, our Institute has been chosen as the venue for their lectures in Bangalore. Last year it was Prof. Anthony Hewish who spoke about the origin of the universe. This year it is another nobel laureate, Prof. S. Chandrasekhar of Chicago who delivered his talk on Newton's *Principia.*

The first astronomy experiment to be conducted by an Indian scientific team is imminent. A team of three scientists, two from our Institute and one from Uttar Pradesh State Observatory, Naini Tal, has reached Antarctica, and is setting up an observing station at Maitree.

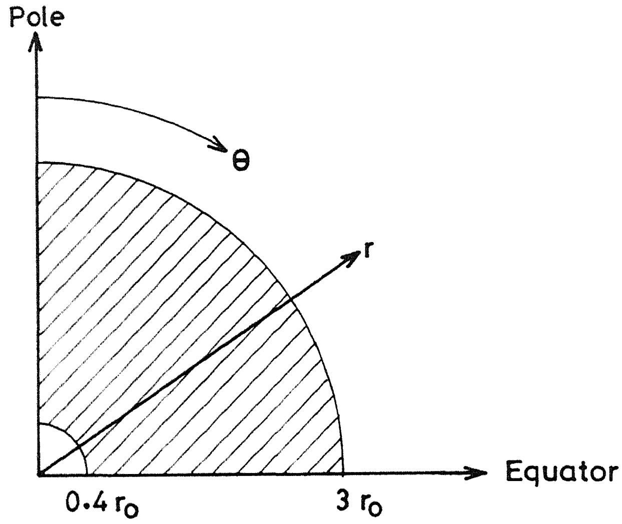
Our observing season has already begun. The major new facility available during this season is the attachment of CCD camera to the focal planes of both the Cassegrain and coudé spectrographs of the Zeiss one metre telescope at VBO. New developments have also been achieved in the Vainu Bappu Telescope environment, which is being reported appropriately in the VBT News.

J. C. Bhattacharyya

2-D Magnetohydrodynamic Model of the Solar Wind

The solar wind is basically an extension and expansion of the solar atmosphere into interplanetary space. The solar wind consists of a stream of charged particles—protons, electrons and other ionized particles. The thermal and magnetic energy in the sun's corona is converted into the kinetic energy of the bulk flow of the solar wind. As a result of internal solar motions of dense plasma a strong intrinsic magnetic field is generated below the photosphere. Some field lines return in 'closed' structures to the sun while others are pulled by the solar wind plasma into outer space. In between the closed fields there are open field regions—called 'coronal holes'—from which the bulk of the solar wind originates. There are also open field lines overlying the closed fields. These are called coronal streamers.

Coronal streamers and coronal holes reflect the large-scale coronal magnetic field geometry. The structures are long-lived, lasting several days or weeks. The open field regions are so called because they are magnetically open to the interplanetary medium. Densities are higher in the open field regions of streamers than in the holes. Because of the field topology in the coronal holes they are considered to be the natural sources for the solar wind. Observations confirm a correlation between the speed of the solar wind and size of the coronal holes, with the highest speed solar wind originating in the largest coronal holes.



Geometry of the model: r_0–distance to the sonic point; r–radial distance; θ–co-latitude.

There are at least three distinct physical regimes in the global structure. Low in the corona, below the tops of the closed regions, the magnetic pressure dominates thermal and dynamic pressures so that the topology resembles that of a purely potential magnetic field. High in the corona, well above the tops of the closed regions, the flow is very nearly radial and the flow properties are controlled only weakly by the magnetic field. In the intermediate region the Lorenz force is comparable to thermal pressure gradients. In this region therefore it is not possible to make any simplifying assumptions regarding the relative importance of the magnetic, thermal and rotation terms. The problem is geometrically complex and highly nonlinear requiring a numerical solution.

The effect of rotation on the field structure is to produce an Archimedes spiral (Parker's model). The spiral nature of the field has been confirmed by spacecraft observations. The acceleration of the solar wind and the modification of the field due to the underlying coronal magnetic field have been studied without incorporating rotation by several authors. The general model is a 2-D solar wind with azimuthal symmetry and symmetry about the rotation axis, so that only the region between the pole and the equator is studied ('split-monopole' model). In the current model rotation (azimuthal motion) is included in the figure. This implies that all the three components of magnetic field and velocity field have to be computed.

The problem is treated as an initial-boundary-value problem on a spherical coordinate grid. A method developed for applying radiation boundary condition for MHD waves is applied at the inner and outer boundaries and symmetry conditions are used along the pole and the equator. The equations of continuity, motion and the induction equation are integrated at each time step until a steady state is reached. The steady state is determined by checking the invariants of the system such as the Bernoulli integral **E**, specific angular momentum **J** and angular velocity **K**. The equations are modified to reflect non-dimensional form so that the model can be used for stellar winds as well. A constant supply of matter at the inner boundary is assumed and radial component of the magnetic field is calculated using a spherical field configuration. The initial velocities are computed using a force-free field assumption. The simulation uses a 4 step Runge-Kutta time integration and a finite-differences approximation to integrate the equation.

C. T. Vanajakshi

Star Formation-Simulation of the Dominant Process in Early Stellar Evolution

Formation of a star or stars with or without planetary systems depends vitally on the conditions and processes at the initial stages of stellar evolution. Whether the final configuration is a binary or multiple system or a single-star with an accretion disc that eventually gives rise to a planetary system depends on how effectively angular momentum is redistributed in the 'placental' cloud—called the protostellar cloud—that collapses to form the star (or stars).

Stars form in dense gas-dust complexes called molecular clouds which form in the interstellar medium. The molecular clouds undergo fragmentation and form association of protostellar clouds which undergo gravitational collapse to form a system of stars or a solar nebula —a central star surrounded by an accretion disc. The conditions prevailing in the protostellar clouds are not well-known because the clouds are very cool (10 K) and cannot be observed with the available technology; we can only infer the probable conditions in these clouds. Based on observations of molecular clouds it seems highly probable that many of these clouds have some degree of turbulence and a magnetic field. In addition, all molecular clouds rotate to a greater or lesser degree, and the protostellar clouds will also inherit this rotation.

If the conditions in the cloud are such that the gravitational energy is greater than the sum of thermal and other (such as magnetic) energies (which will act against the contraction) the cloud will collapse and accumulate mass at or near the centre. As the contraction proceeds, matter in the interior of the cloud spins faster in order to conserve angular momentum. Eventually the centrifugal force becomes comparable to or greater than the gravitational force and halts the collapse near the core of the cloud. Mass from the outer parts of the cloud falling towards the centre, is thrown out to form a toroidal ring whose radius is dependent on the initial rotation. Once this 'ring' forms it acts as a gravitational potential well and continues to accumulate mass. Eventually this ring can fragment to form a binary or multiple system; but, in this scenario, it is difficult to form a single star with a surrounding protoplanetary disc.

If, on the other hand, some mechanism acts during the early stages of the collapse, fast enough and efficient enough, to redistribute angular momentum from near the centre to the outer regions of the cloud, the mass that falls towards the centre can stay there and form a core that becomes the protosun. Turbulent viscosity, magnetic redistribution through propagation of Alfvén waves and stellar winds are three of the major mechanisms touted as possible candidates to effect this transfer. To study any one of these processes needs a full numerical simulation because the problem is highly nonlinear and is not susceptible to an analytical solution.

We have developed 2 and 3 dimensional models of collapsing clouds with turbulent viscosity/magnetic fields to study their efficacy in angular momentum transfer. Starting with a uniform density cloud in rigid rotation we follow the collapse by integrating the fluid equations including turbulent viscosity/magnetic field. In the model for turbulent viscosity, the coefficient of viscosity is derived from the local shear so that the model is sensitive to local gradients which can vary steeply near the centre of the cloud as the collapse proceeds. The sensitivity of the collapse to initial conditions in the cloud is studied by putting in random density and/or velocity fields at time $t = 0$. Sensitivity to initial degree of turbulence is studied by introducing a mild initial turbulence with a Gaussian distribution of turbulent velocities. Previous calculations which followed the collapse of a non-turbulent, non-magnetic rotating cloud have given rise to controversial results—some giving a final configuration of rings and some ending in a central core acting as an accretion disc, often depending on the method and details of the calculation. Nevertheless, the consensus of opinion is that eventually a ring will form, and fragment in the later stages of the collapse.

The numerical scheme used was the same as that of Black and Bodenheimer (1975, 1976), where the grids move approximately along the collapsing matter. Along the equator and the rotation axis the movement of the grid follows the mass exactly. Since we assume azimuthal symmetry and there is reflection symmetry along the equator, only one quarter of the cloud is studied. We used a cylindrical coordinate grid, with R axis along the equator and the Z-axis along the rotation axis. All the three velocities are evaluated but $\partial/\partial\phi$ terms are set to zero because of the assumption of azimuthal symmetry. Other assumptions included isothermal collapse, a composition of pure molecular hydrogen. In addition, radiative transfer was ignored since the cloud is optically thin at this stage of the collapse. Initial conditions assumed appropriate for this phase of the collapse are: density $1.376 \times 10^{-18}\ \mathrm{g\,cm^{-3}}$; mass $1\ M_{\odot}$ (1.99×10^{33} g); temperature 10 K, total angular momentum: $1.35 \times 10^{54}\ \mathrm{g\,cm\,s^{-1}}$; initial radius: 7×10^{16} cm; α (thermal/gravitational energy) 0.52; β (rotational/gravitational energy) 0.1036 and angular velocity $\Omega = 3.5 \times 10^{13}\ \mathrm{s^{-1}}$ at $t = 0$.

It is found that even random variations in initial velocities or density give rise to a central core or a ring of very small radius depending on the degree of initial rotation, initial velocities even for fairly small coefficients of turbulent viscosity. Even a small degree of initial turbulence gives rise to runaway collapse at the centre. This problem is being studied in greater detail at present using the Vax 11/780 at Kavalur.

The problem of collapse of a rotating, magnetized protostellar gas cloud has been modelled as a full 3-D simulation. The cloud is assumed to be isothermal and the magnetic field is assumed to be 'frozen in' to the gas. As a starting model a uniform density gas sphere in rigid rotation is used. We have used different field orientations—**B** parallel to the rotation axis, **B** parallel to the equator and **B** inclined at 45° to all the three axes.

A spherical coordinate grid is used and the grids are moved approximately along with the gas consistent with the divergence conditions for mass and the magnetic field.

An outstanding problem in this simulation is the development of radiation boundary conditions for the outgoing MHD waves consistent with the needs of the severe restrictions imposed by the wide variations in density (over a range of million) and velocity between the core of the cloud and the outer regions as the collapse proceeds.

Rigorous radiation boundary conditions for MHD problems developed during the course of this simulation (Vanajakshi, Thompson & Black 1989) cannot be applied in this specific problem because the velocity values near the boundary have to be artificially clipped (as the collapse progresses) in order to keep the time steps reasonably large. Such artificial clipping interferes with the rigorous mathematical mechanism of the radiation boundary condition method developed earlier.

Developing a reasonable set of boundary conditions is one of the on-going research projects here at IIA.

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C. T. Vanajakshi

20-inch Reflector by Grubb (The Bhavnagar Telescope)

The first ever modern, astrophysical observatory in India was the Bombay government's observatory at Poona, named after Maharaja Sir Takhtasingji, G.C.S.I. of Bhavnagar, whose 1882 grant of Rs.5000 had formed its nucleus.[1,2] The observatory was the result of the efforts of Kavasji Dadabhai Naegamvala, M.A., F.R.A.S. (1857–1938), a protege of Sir Norman Lockyer. On Naegamvalas' retirement in 1912, the observatory was disbanded and all the equipment transferred to the Indian government's solar physics observatory at Kodaikanal.

The major instrument at Poona was a large reflector by Sir Howard Grubb. Before being shipped to India it along with the £250 dome was inspected in 1887 or 1888 by Thomas Cushing F.R.A.S at India Office's Lambeth Observatory.[3] The building at Poona was ready in 1888 but the reflector was not installed till the end of 1890 (ref. 1).

The Grubb reflector at that time was 16½ inch aperture silver-on-parabolic glass Newtonian with a 4 inch finder attached.[4] Interestingly Naegamvala's first use of the telescope was to prove his mentor wrong.

Using his 16½ inch reflector and three different spectroscopes,[5] Naegamvala showed in 1891 that the chief nebular line was sharp under all circumstances and therefore could not be the remnant of a magnesium band, as Lockyer had suggested. Thus the assertions of William Huggins and James E. Keeler were right.[5,6]

Lockyer's bland summary of Naegamvala's effort makes interesting reading. Writing about Poona Observatory in 1898, he wrote.[1]

> Some spectroscopic work of preliminary character was done during 1891, but it was found that the instrument used was altogether lacking in stability and was very weak in its driving parts. It was thereupon returned to Sir Howard Grubb for radical alterations.

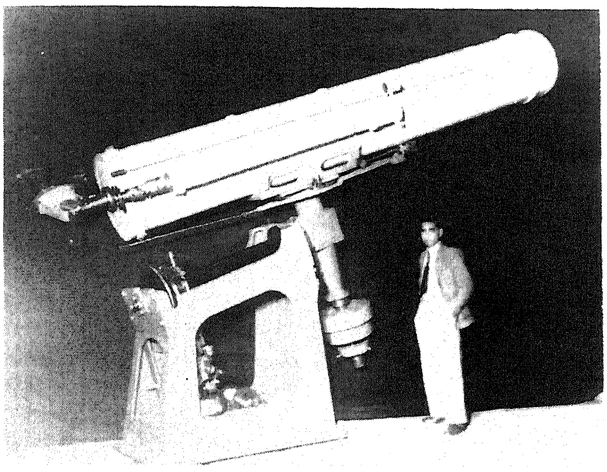
The modified telescope was received back in 1984. It was now 'a Cassegrain reflector of 16½ inch aperture and 127 inch focus, adapted both for visual and photographic work, and supplied with electric control'. To this was attached a 6 inch achromatic finder with filar micrometer and solar eye piece.[7]

The last recorded use of this version of the telescope was during 16–18 April 1896 (ref. 8). In 1897 the 16½ inch mirror was replaced by a 20 inch mirror by Dr A. A. Common.[1] Whether Naegamvala's being a member of 1986 solar eclipses expedition to Norway under the leadership of Common had anything to do with the change we cannot say. On 10 October 1896 Naegamvala wrote to W. H. M. Christie from London itself[9]

> By April next the equipment of my Observatory will consist of [among others] a 20″ Reflector 11′-3″ focus, with a six inch guider, mounted on a stand very nearly the same as that of Grubb's 13″ astro-Photographic telescopes.

No results using this telescope appear to have been published.

The telescope was part of the equipment that came from Poona, but Kodaikanal had no real use for it. While the instruments relevant for solar studies were put to use with alacrity, Inida's largest telescope was to remain in boxes for four decades.



The 20 inch Grubb reflector (the Bhavnagar telescope) after assembly in 1949 or 1950. Photographed with the then director Dr Anil Kumar Das, at the Kodaikanal Observatory workshop.

In 1912 itself John Evershed, the Director of Kodaikanal Observatory took up with the government the question of constructing a building for the Poona telescope, but there was then a serious move to shift the Observatory to Kashmir. The construction of a building was therefore 'held over for the present.[10]

Kashmir was not found to be any better than Kodaikanal but the Bhavnagar telescope's fortunes did not change. Its mounting however was erected, the driving clock repaired, and a 8″ horizontal telescope also from Poona was attached to it (1918–19). Nothing came out of it, however.

It was only 30 years later, in 1949, that the question of the installation of the telescope was taken up. The telescope was reassembled its missing parts being fabricated (Figure 1) and the construction of the dome taken up. Finally, the Bhavnagar telescope was 'inaugurated' in July 1951 as part of the celebrations of the golden jubilee year of the Observatory's 'commencement of systematic solar observations with the equipment available at the time.[11]

The telescope remained in use at Kodaikanal for 26 years. In about 1978 the telescope tube was disconnected from the mounting and shifted to Kavalur Observatory, where it was installed on a home-made mounting (J. C. Bhattacharyya, personal communication). In 1984, the original mounting was brought from Kodaikanal, and re-united with its telescope tube. Remodelled, the Bhavnagar telescope was airlifted from Bangalore to Leh, Ladakh, for installation at the nearby village of Skara. It was used there till November 1988 for site survey work under the auspices of India Government's department of science and technology[12]. It is now waiting to be despatched back to Kodaikanal.

I thank Mr. P. S. M. Aleem for the photographic work.

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R. K. Kochhar

newsline

R. K. Kochhar has been nominated a member for 1990–92 of the Advisory Board (Modern Period) on History of Science. This board works under the auspices of what has now been renamed as Indian National Commission for History of Science. Kochhar is also a member of the Commission.

David Lambert of the Department of Astronomy, University of Texas, Austin visited IIA between 1989 December 6 and 27. His visit was in connection with the collaborative programme with N. Kameswara Rao and Sunetra Giridhar on the spectroscopic study of hydrogen deficient stars. In addition to this, he gave lectures at IIA, RRI and VBO, Kavalur, on various aspects of elemental abundances and nucleosynthesis in evolved stars.

Dr. A. Arellano Ferro of the Institute of Astronomy, National University of Mexico is visiting IIA between 1989 November and 1990 May. He is collaborating with Sunetra Giridhar on the comparison of spectroscopic properties of normal massive F-G supergiants with those of peculiar high galactic latitude counterparts. They propose to incorporate spectroscopic parameters of luminosity-sensitive features such as O I 7773 to the *uvby* β colour indices in search of a more accurate luminosity calibration for estimating stellar distances. Arellano Ferro's trip is financed by the Third World Academy of Sciences.

Dr. Firuz Sahibov of the Institute of Astrophysics, Tajik Academy of Sciences, Dushanbe, is visiting IIA under the INSA–USSR Academy of Sciences bilateral exchange programme. Sahibov's research interests include kinematics, star formation, and supernovae in spiral and irregular galaxies. During his stay at IIA between 1989 December and 1990 May, Sahibov will collaborate with Y. D. Mayya and T. P. Prabhu on (1) photometric and chemical evolution of star formation complexes in external galaxies by comparing narrow, medium and broad band photometric data as well as spectrophotometric data with semi-empirical models; (2) the age gradient in spiral arm star formation complexes estimated by the technique developed by Sahibov earlier for observational detection of corotation radius in spirals.

out of context

The observation . . . supports the TNR theory as the cause of the outburst . . . .

Classical Novae (1989), John Wiley, p. 44.

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