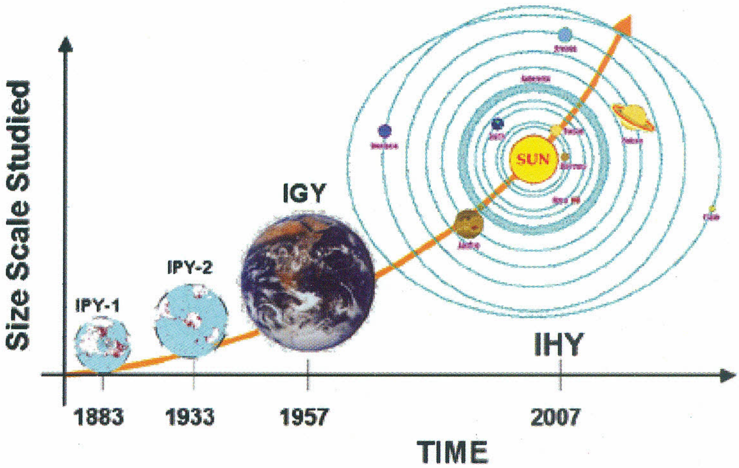
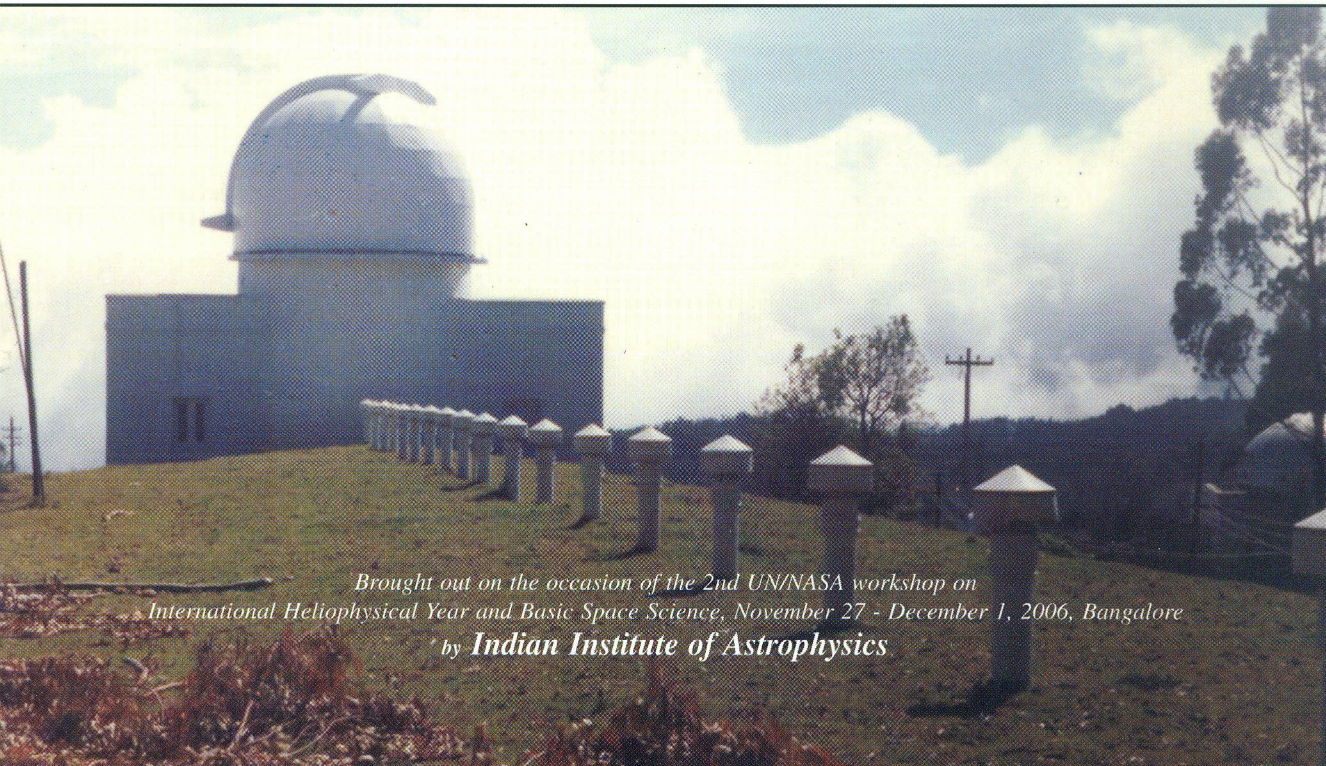



# Highlights of scientific activities in India during the International Geophysical Year

# IGY 1957 – 1958



*Brought out on the occasion of the 2nd UN/NASA workshop on International Heliophysical Year and Basic Space Science, November 27 - December 1, 2006, Bangalore*

*by* ***Indian Institute of Astrophysics***

**Mrs. & Prof. S. Chandrasekhar seen with Prof. M.K.V. Bappu during their visit to Kodaikanal in November 1961.**

**Front Cover (lower half) : Solar Tunnel Telescope at Kodaikanal Observatory**

# Foreword

Processes in the solar atmosphere occur on time scales ranging from hours to decades. Understanding of these processes is important both in the context of the Sun as a star and as a driver of space weather that has terrestrial consequences. One common thread that links the cause and effect is the presence of plasma and magnetic fields. The plasma in the Earth's magnetosphere, being transparent to ground–based observers, permits diagnostics that are limited to the geomagnetic fluctuations and probing of its outer atmosphere by remote sensing. However, in the recent past these have expanded beyond expectations, with *in situ* measurements of the magnetic field, physical properties of the plasma and of the particle streams in the magnetosphere of the Earth through space missions. The scientific community is now poised to study in greater detail the microstructure of dynamic events on the Sun occurring in the smallest of structures such as thin magnetic fibrils, as well as of those in the magnetosphere of the Earth and in the interplanetary medium. For instance shocks are believed to play a major role in the acceleration of particle streams in the solar corona; similarly, shocks are observed *in situ* in the interplanetary medium and it has been seen that standing bow shocks and termination shocks separate major regions in the heliosphere. It is thus appropriate that the shock formation and particle acceleration have been identified as one of the themes of study in the International Heliophysical Year (IHY) programme. This needs a cross fertilization of ideas between experts in solar physics and space weather. The IHY programme has been conceived with this agenda in view. The International Polar Year (IPY) and more specifically the International Geophysical Year (IGY) programmes in the past have demonstrated the immense potential residing in scientific co-operation over the globe and the magnificent returns that the scientific community can gain from such an effort. The IHY broadly follows the IGY pattern, but with a more enhanced scope. With more observing facilities, it takes a further step to study physical mechanisms occurring on the Sun and their impact on the interplanetary medium. Further, the IHY studies would view the Sun, the Earth's magnetosphere and the interplanetary medium as a coupled system and reach out to the outermost boundaries of the interplanetary medium where it merges with the interstellar medium. Another remarkable feature of IHY is the outreach education programme through which the importance of these studies will be disseminated to the general public and more importantly used to inspire the next generation of space scientists who are still in schools and universities. By timing the IHY to coincide with the 50th year after the IGY, the scientific community reaffirms its faith in similar international cooperative efforts. Major scientific institutions in India functioning then and a few university centres participated effectively in various IGY programmes. Subsequently, there has been a major augmentation of ground-based observing facilities for monitoring the Sun at Kodaikanal and Nainital and for probing the ionosphere (using digital ionosonde) at Kodaikanal. More recently, additional facilities have been created such as the Ooty radio telescope for monitoring the interplanetary scintillations; the Giant Metrewave Radio Telescope (GMRT) near Pune; the

Gauribidanur radioheliograph near Bangalore for imaging the solar corona; the Udaipur Solar Observatory for monitoring activity on the Sun in the optical region; the MST Radar facility at Gadangi near Tirupati for probing the Earth's neutral atmosphere. Furthermore, facilities have also been created for atmospheric modelling along with new capabilities in this field. There are also on-going programmes of rocket sounding of the Earth's atmosphere (both neutral and plasma) and launching of a solar mission payload on an Indian satellite. India is now ready to play a significant role in participating in IHY programmes, which will provide fresh opportunities to solve many of the outstanding problems in solar and terrestrial physics.

**S.S.Hasan**
**Director**
**Indian Institute of Astrophysics**
**Bangalore 560 034**

# Highlights of scientific activities in India during the International Geophysical Year (IGY) programme 1 July 1957 – 31 December 1958

Understanding the Sun has been a continuous quest for mankind since the very distant past. The role of magnetic fields on the Sun in governing the complex processes that drive solar activity and variability has been one of most exciting problems for the community of solar astronomers. The hypothesis that many dynamic phenomena occurring on the Sun determine the nature of the interplanetary medium in general and near–Earth environment in particular earned more acceptance with the introduction of the concept of the "Solar Wind" by Biermann in 1951. In 1957, Chapman postulated the possibility of coupling of the solar magnetic field with that of Earth which could then provide a channel for the flow of the charged particles discharged from the sites of energetic events on the Sun towards the Earth and cause magnetic storms and polar auroras. The energetic component of the electromagnetic radiation from Sun in EUV, XUV and X-ray wavelength bands were supposed to be responsible for the creation of the ionized layers enveloping the Earth. These hypotheses needed verification.

The main visionaries, Sydney Chapman on the International scene and K.S. Krishnan on the National scene conceived the imperative need to study both the phenomena on the Sun and the corresponding resulting phenomena on the Earth's ionosphere and the geomagnetic field. They timed this programme of study to coincide with the high solar activity phase (1957–1958) which turned out to be the period of highest sunspot activity ever before and after. This coordinated campaign by a chain of stations spread over 66 nations well distributed to have the best longitude coverage over the globe and latitude coverage (about the geomagnetic equator) has been one of the most successful cooperative scientific efforts by mankind. The observational programme extended over 14 major fields and India took part in every one of the fourteen divisions of the International programme.

On the national scene, Kodaikanal Observatory that had started functioning since the very beginning of the last century (with a glorious heritage of achievements over a century earlier of the erstwhile Madras Observatory) played a vital role during the IGY period. Equipped with solar instrumentation on par in quality and standards of performance with those elsewhere in the world at that time, Kodaikanal Observatory, functioning as part of India Meteorological Department, secured observations of the Sun by an intensive monitoring of solar activity. Observations of the Earth's ionosphere, geomagnetic field and monitoring of the ozone along with the regular registration of meteorological parameters, were also carried out there. Two sets of magnetic variographs were received from Askania-Werke, Berlin and tested for installation at the IGY field stations in South India.

Geomagnetic observations were done very comprehensively at the Alibag Observatory. Annamalainagar and Trivandrum stations were established for augmenting observations around the geomagnetic equator, under the leadership of the Colaba and Alibag Observatories, Bombay, which also functioned as part of India Meteorological Department. Within India, other centres like the Radio Propagation Unit of National Physical Laboratory (NPL), New Delhi; Physical Research

Laboratory, Ahmedabad; Physics Department, University of Poona; Andhra University, Visakhapatanam; Osmania University, Hyderabad; contributed significantly by monitoring of the solar radio noise, Earth's ionosphere, airglow, etc. The Radio Propagation Unit of NPL, New Delhi coordinated activities at the different centres within the country by communicating the Alert Intervals and acting as the National Data Centre under the leadership of Dr. A. P. Mitra.

The Kodaikanal Observatory that already had a long tradition of close interaction with centres of solar research like the Mt. Wilson Observatory in USA, Meudon Observatory in France by exchange of data since 1907, participated in the IGY programme in a big way in this part of the globe through an intensive and systematic programme of observations. These were planned well before the commencement of the IGY period and executed during the IGY period and later, through the efforts of scientists under the leadership of Dr. A. K. Das and Dr. B. N. Bhargava. The new IGY code was brought into use from June 1957 for the duration of IGY instead of the previously used URSI code for daily broadcasts of Kodaikanal observations. These activities were made possible by the encouragement and support provided by India Meteorological Department.

# 1. Monitoring of solar activity

**1.1 *White-light images :*** A 6-inch Lerebours and Secretan equatorial refractor of focal length 8 feet (Figure 1) was used to obtain images of the Sun on a daily basis, weather permitting. The image formed by the telescope was magnified to a diameter of 8-inch and was photographed on

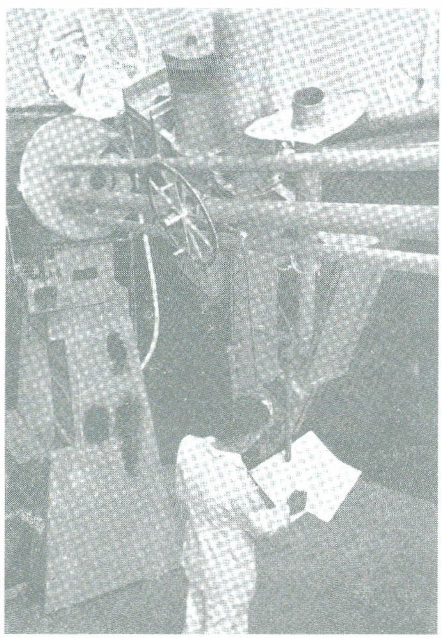


**Figure 1.** 6-inch aperture Lerebours and Secretan equatorial refractor used for daily photoheliograms. Size of solar image in the focal plane: 8 inches.

10×10 inch size Lantern plate. From these photographs, the coordinates and areas of all sunspots and sunspot groups present on the solar disc were measured and the information was communicated to the IGY Data Centre in New Delhi on a daily basis.

**1.2 *Spectroheliograms :*** The twin spectroheliographs, one operating with a band pass of 0.5 Å centered around the $K_{232}$ of the Ca II K line and the other isolating 0.35 Å about the H-alpha line were used to obtain full disc spectroheliograms every day, weather permitting (Figure 2). The two spectroheliographs share a common imaging system that provides a 60 mm diameter solar image. In addition, during the IGY Alert intervals, spectroheliogram sequences that cover active regions in their development phase and subsequent evolution were obtained. Furthermore, during

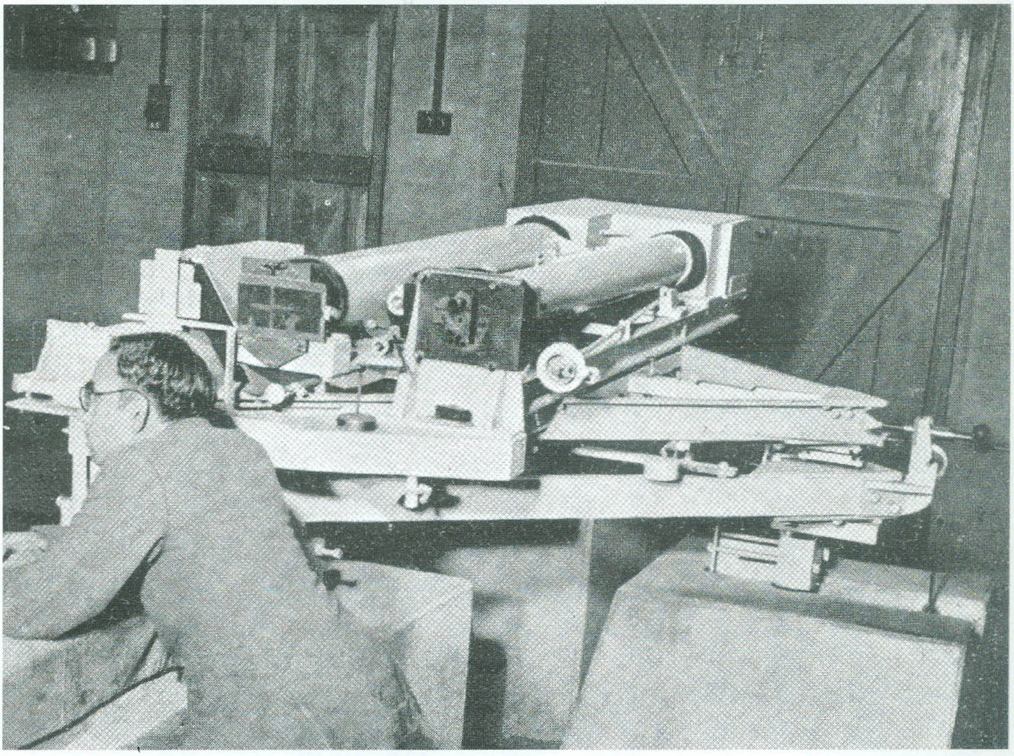


**Figure 2.** Spectroheliograph : One in the front uses two prisms as the dispersing element and the exit slit isolates $K_{232}$ of the profile in Ca II K-line; the H-alpha spectroheliograph in the rear operates with a grating. A common imaging system feeds the two spectroheliographs with a 60 mm diameter solar image.

IGY Alert intervals, rapid scans of the target active regions were obtained. Most of these scans cover the full sequence of evolution: growth of activity (seen in the H-alpha images), mature phase leading to the flare and post flare activity. The details pertaining to the flares were communicated on a regular basis to the IGY Data centre in New Delhi.

**1.3** ***Prominences :*** Observations of prominences were done systematically using a 6-inch Cook refractor on an equatorial mount, with an attached grating spectroscope (Figure 3). These were used to calculate the extent of the prominences in position angle and their heights above the limb.

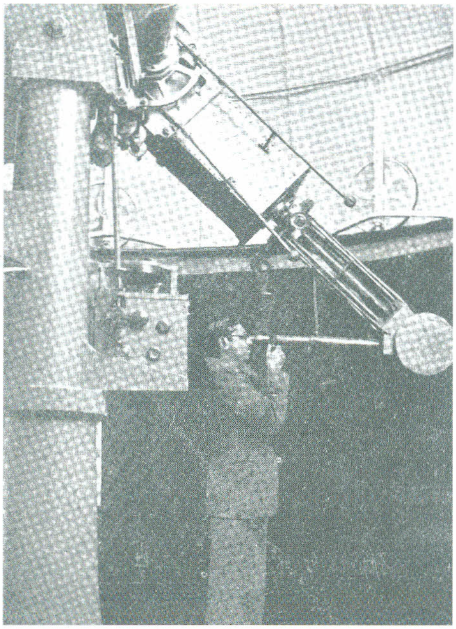


**Figure 3.** 6-inch Cook refractor with a grating spectroscope used for prominence observations.

**1.4** ***Spectroheliosope :*** Spectra of flares and prominences were photographed using a spectrohelioscope and its attached camera (fed by a 5-inch coelostat), simultaneously with visual observations.

The Nizamiah Observatory, Hyderabad participated in the monitoring of solar activity with an H-alpha spectrohelioscope throughout the IGY period.

## 2. Solar-Terrestrial relationship

**2.1** ***Measurements of geomagnetic elements and parameters of the equatorial ionosphere :*** Study of Earth's ionosphere started in India around 1930 at Calcutta University with Prof. S. K. Mitra, almost on par with the efforts elsewhere in the world. In 1949, the activities of Kodaikanal Geomagnetic Observatory were revived after a break with round-the-clock measurements, an activity that continues till to-day (Figure 4). The revival was prompted by the realization of the growing relevance and importance of geomagnetic field measurements to solar phenomena which are being monitored with the co-located optical facilities at Kodaikanal, and that the station lies in close proximity to the magnetic equator. The vision and foresight in establishing these observational facilities paid handsome scientific returns including a few discoveries concerning

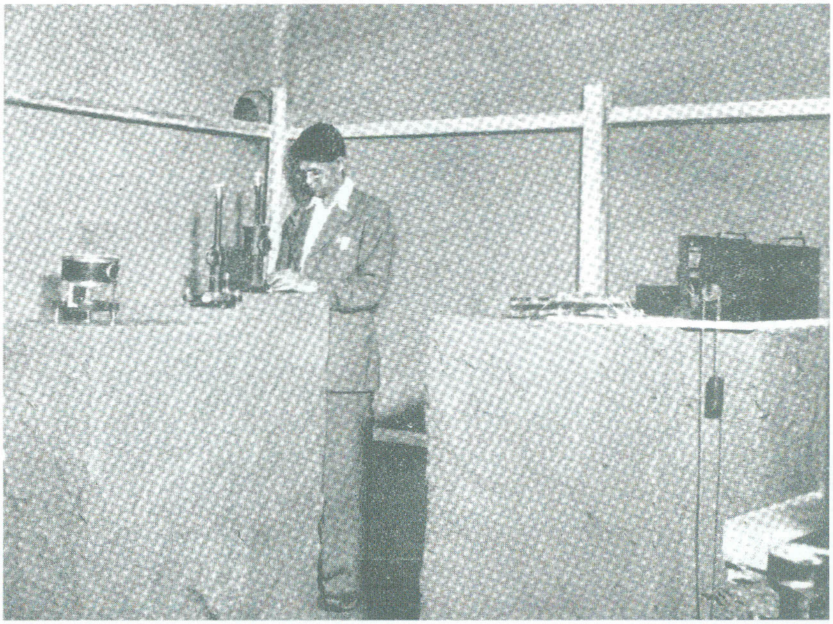


**Figure 4.** La Cour magnetograph.

the Sun and the geomagnetic field, and, above all, the strong and complex coupling between them. For example, the discovery by Egedal and Chapman of the 'equatorial electrojet' (EEJ), an intense, narrow band of ionospheric E-region current that girdles the magnetic equator and gives rise to enhanced solar daily variation of the geomagnetic field there, was made possible by the geomagnetic data of Kodaikanal, Madras and Alibag. This is an outstanding result as subsequent work showed that EEJ and the electric field that drives it respond very sensitively to solar and interplanetary variability on various time scales.

The 1950's witnessed a surge of ionospheric studies at a number of institutions in the country through the formation of new research groups, at Physical Research Laboratory, Ahmedabad, National Physical Laboratory, New Delhi and a few universities, notably Andhra University, Visakhapatanam. Manual hourly ionospheric soundings were made at several stations under the aegis of All India Radio. A CRPL model C-3 automatic ionosonde (Figure 5) was installed at Kodaikanal Observatory in 1952 and round-the-clock quarter-hourly soundings began in 1955. Regular soundings with automatic ionosondes were also started at Ahmedabad and Calcutta. An Askania Field Balance for Vertical Magnetic Force was also commissioned at Kodaikanal Observatory in 1958.

In response to recommendations by Prof. K. R. Ramanathan, Chairman, Indian National Committee for IGY, geomagnetic observatories were established at Trivandrum and Annamalinagar, and

**Figure 5.** CRPI model C-3 automatic ionosonde.

ionospheric sounding facilities at Trivandrum and Trichinapally. During the International Quiet Sun Year (IQSY) programme that followed in early sixties, the magnetometer network was strengthened with the addition of stations at Sabhawala, Dehra Dun by the Survey of India and at Hyderabad by the National Geophysical Research Institute. Many hitherto unknown features of the equatorial electrojet and equatorial ionosphere were brought to light by the magnetometer and ionosonde database at Kodaikanal, when studied either in isolation or in combination with data of other stations. This was achieved not only by in-house researchers but also by numerous others at many organizations both in India and abroad. That was made possible by the pragmatic policy of contributing the data not only to the World Data Centers (WDCs) and National Centers like National Physical Laboratory, New Delhi and Indian Institute of Geomagnetism, Mumbai for inclusion in the Indian Ionospheric and Geomagnetic data bulletins, respectively, but also making the original/ processed data freely available to interested scientists the world over. This tradition and policy continues till to-day.

### 2.2 *Radio observations :*

**2.2.1** ***Atmospherics :*** The response characteristics of the ionosphere to solar flares vary markedly over the frequency range 10 kHz to 100 MHz. At low frequencies (10 kHz to 500 kHz), the effect is of sudden enhancement of intensity of atmospherics and above 500 kHz, the effect is one of fade out due to sudden increase in absorption of the medium and short radio waves. During IGY period, observations of both enhancement as well as the absorption were carried out at National Physical Laboratory, New Delhi, over an extended frequency ranging from 27 kHz to 25 MHz, to monitor solar flares, by Dr. A. P. Mitra and his group.

**2.2.2 *Ionospheric Absorption :*** The changes in absorption can be studied using terrestrial transmission and also by receiving radio emission radiated from our galaxy. A radio telescope was built and operated at 25 MHz by the Physical Research Laboratory, Ahmedabad for dedicated measurements of absorption and the diurnal, seasonal variations in the intensity of cosmic radio noise arising from the varying ionospheric absorption characteristics. The instrument was operated over the IGY period and beyond.

Diurnal variation of ionospheric absorption at 5.65 MHz was systematically studied at the Andhra University, Visakhapatanam. In addition, $F_2$ region drifts were also measured to monitor the solar activity. Extensive monitoring of changes in the structure of various layers of the ionosphere was performed at the National Physical Laboratory, New Delhi.

## 3. Optical tracking of artificial satellites

Accurate measurements of the position of a satellite at various known instants form the basic data for deriving orbital characteristics. The orbits of satellites are perturbed by

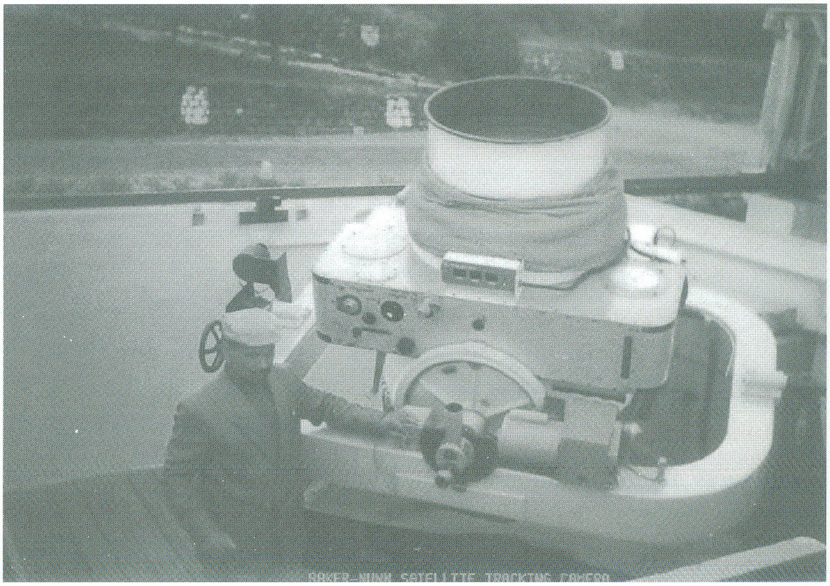


**Figure 6.** Baker-Nunn satellite tracking camera at the Uttar Pradesh State Observatory, Nainital. This camera has a 20-inch aperture f/1 Schmidt system in an alt-azimuth system.

effects due to atmospheric drag, gravitation anomalies and the oblateness of the Earth. The nature of these perturbative and the secular changes in the orbital characteristics can be studied only by continuous observations of the position of satellites with high accuracy by a network of stations. Optical tracking of artificial satellites were done photographically on a systematic basis during the IGY period at the Uttar Pradesh Sate Observatory (UPSO), Nainital, under the leadership of Dr. M. K. Vainu Bappu and Dr. S. D. Sinvhal using the 20-inch Baker-Nunn camera (Figure 6). The UPSO was one of the twelve photographic stations encircling the globe organized by the Smithsonian Observatory, USA for satellite tracking programme. The UPSO also functioned as one of the stations in the world-wide network for lunar photography using a Markowitz camera fed by a 10-inch refractor.

## 4. Atmospheric ozone, integrated solar radiation and cosmic ray measurements

Systematic observations of atmospheric ozone were conducted using Dobson spectrophotometer by the India Meteorological Department from its stations at New Delhi and Kodaikanal and independently by Physical Research Laboratory from Mt. Abu.

Measurements of the total solar radiation, integrated over all wavelengths were conducted from a few selected stations over the country, using pyroheliometers by India Meteorological Department.

Cosmic ray measurements were done by Physical Research Laboratory from its high altitude station at Gulmarg.

## 5. Seismology

The India Meteorology Department has a network of stations where seismographs have been working since a long time. These stations are: Shillong, Bombay, New Delhi, Dehra Dun, Tocklai in Assam, Bokaro in Bihar and Madras. In addition to these, 3 more stations were established at Hyderabad, Vizianagaram and Chatra (operated by the respective State Governments) and operated during the IGY period.

## 6. Oceanography

To detect the short and long time changes in the sea level and the general circulation of water in the oceans, an observing programme was conducted by the oceanography wing of the Central Board of Geophysics. These consisted of measurements of surface temperature and salinity extending up to 20 miles into the ocean at Bombay, Cochin and Visakhapatanam harbours, during the IGY period.

The large amount of observational data collected by the participating institutions has been analyzed and the papers on the scientific results can be accessed from the following journals:

1. *Journal of Scientific & Industrial Research (1958), Vol. 17A, No. 12* published by The Council of Scientific and Industrial Research, New Delhi.

2. *Proceedings of IGY Symposium (1961), Vol. 1 & 2* published by The Council of Scientific and Industrial Research, New Delhi.

**Back Cover :** Kodaikanal Observatory campus - Library building (front), Solar Tunnel Telescope (middle) and Spectrograph building (rear)

**Indian Institute of Astrophysics**
Koramangala, Bangalore - 560 034
www.iiap.res.in