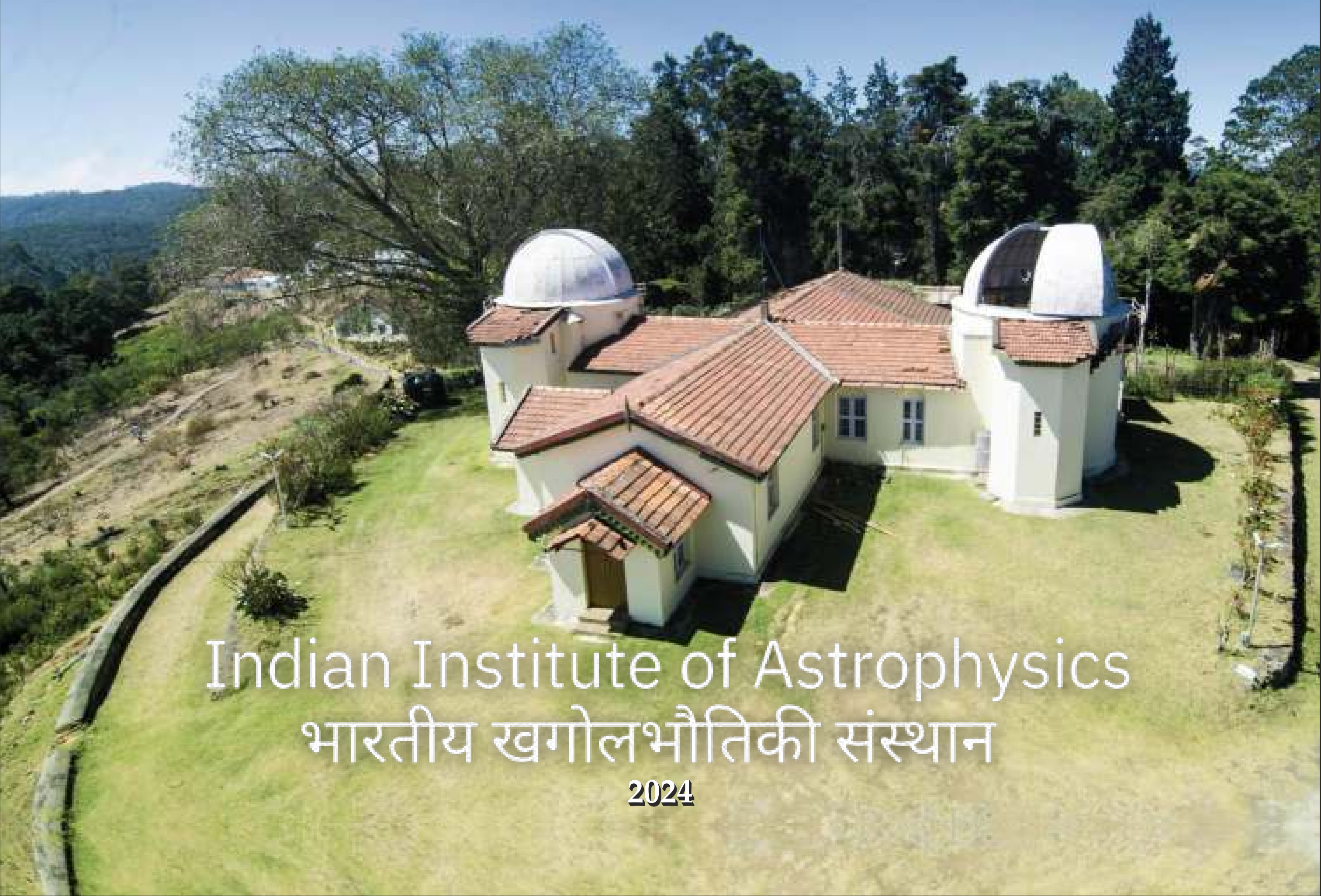
Celebrating 125 Years

Kodaikanal Solar Observatory

125 Years Under the Sun

A Chronicle of the Kodaikanal Solar Observatory



Indian Institute of Astrophysics

भारतीय खगोलभौतिकी संस्थान

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Kodaikanal Solar Observatory:

125 Years of Astronomical Brilliance

Established in 1899, the Kodaikanal Solar Observatory was envisioned to further studies in astrophysics, with a thrust in solar physics. Over the decades, KSO has evolved, incorporating cutting-edge technologies and research methodologies to study the sun. Its strategic location, at an elevation of over 2,300 meters, offers a unique vantage point for solar observations, largely unaffected by the atmospheric disturbances common at lower altitudes.

One of the observatory's most significant contributions to the field is its comprehensive solar data archive. The meticulous daily recordings of solar observations have created a treasure trove of information, making KSO a crucial link in the global chain of solar observatories. This continuous data, spanning over a century, provides invaluable insights into solar cycles, sunspot activities, and solar flares, contributing to our understanding of the sun’s impact on Earth’s climate and space weather phenomena.

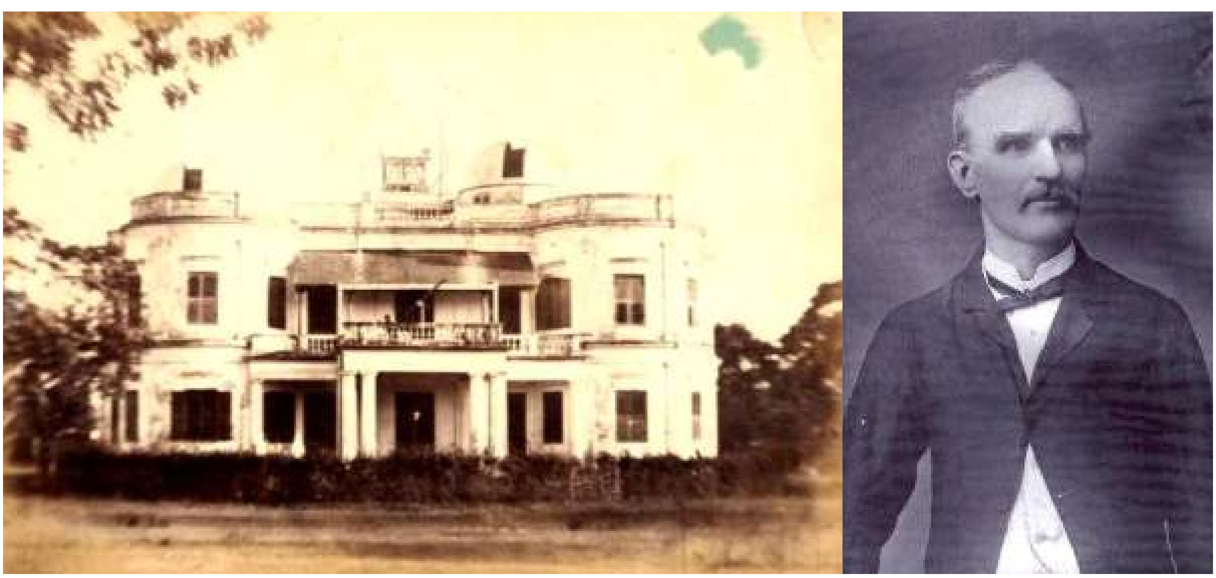
As we commemorate 125 years of the Kodaikanal Solar Observatory, its legacy is not just in the discoveries made but in the continued promise it holds for the future of solar research. In an era where understanding our sun is more crucial than ever, given its implications on technology and climate, KSO's contributions are invaluable. It stands as a beacon of India’s commitment to scientific exploration and discovery, highlighting the nation’s role in the global scientific community.

The observatory's journey through the years encapsulates the spirit of inquiry and perseverance. As we look forward to the future, the Kodaikanal Solar Observatory is poised to continue its exploration of the cosmos, contributing to our collective quest for knowledge. In doing so, it not only upholds a rich legacy but also inspires a new generation of scientists to gaze skyward, in pursuit of the unknowns that lie beyond.

1. From Colonial Roots to Solar Pioneer (1787 -1898)

The Kodaikanal Observatory has its roots in the colonial era, tracing its origins back to the East India Company's (EIC) establishment, in 1789, of an observatory in Madras "for promoting the knowledge of astronomy, geography and navigation in India". Precursor to this decision of EIC was a private observatory set up by William Petrie, an officer with EIC, in 1786 with three 2.75 inch telescopes and an astronomical clock, which passed from Petrie's ownership to Madras Observatory under its first director Michael Topping.

By the early 19th century, the Madras Observatory had established itself as a leading astronomical center, particularly known for its work on star positions. Astronomers like John Goldingham, T. G. Taylor, W. S. Jacob, and Norman R. Pogson led the facility's activities, contributing significantly to the field. One notable achievement was the production of a comprehensive catalogue of 11,000 southern stars in 1844.



The Madras Observatory as it appeared around 1860 and its director (1861 – 1891), Norman Pogson.

Norman Pogson, a renowned astronomer associated with the modern magnitude scale, arrived in 1861. He actively used a new transit circle telescope, measuring positions of nearly 50,000 stars until his passing in 1891. He also led expeditions to observe three total and one annular eclipse of the Sun during this period.

The 1868 total eclipse held historical significance. Spectroscopes were used for the first time, revealing a new line in the Sun's spectrum, later identified as helium by Norman Lockyer. This discovery marked a crucial moment in solar physics. Additionally, observations during the eclipse confirmed the gaseous nature of prominences.

Recognizing the need for a larger telescope, Pogson proposed a 20-inch instrument in 1882. The search for a suitable location led to Michie Smith's survey of the Palni and Nilgiri Hills in 1883-1885, seeking optimal conditions for both day and night observations. However, delays arose due to concerns about Pogson's work load.

Meanwhile, the British government, interested in the potential connection between solar activity and monsoon patterns, established the

Solar Physics Committee (SPC) in 1879. Their recommendations and those of the Indian Observatories Committee formed in 1885 ultimately paved the way for a new observatory dedicated to solar physics. Following Pogson's death in 1891, a series of initiatives culminated in the establishment of the Kodaikanal Solar Physics Observatory, marking a shift in focus and the beginning of a new era in solar research in India.

2. From Madras to the Mountains: Birth of the Kodaikanal Solar Observatory Seeds of Change

In October 1891, John Eliot, the Meteorological Reporter to the Government of India, initiated discussions regarding the future of the Madras Observatory. The Secretary of State, influenced by the Astronomer Royal, envisioned a new, larger observatory dedicated to both "astronomical work proper" and "astronomical physics," particularly solar observations. Eliot, recognizing the need for a more conducive location and specialized focus, recommended relocating the observatory to a hill station with improved climate and prioritizing solar physics research.

Finding the Perfect Site

A meticulous search for a suitable location ensued, with Kotagiri in the Nilgiris and Kodaikanal in the Palnis emerging as frontrunners. After Pogson's passing, Michie Smith was entrusted with surveying both sites and submitted a detailed report favoring Kodaikanal in August 1892. He based his recommendation on extensive observations of various celestial objects and atmospheric conditions. Both the Solar Physics Committee (SPC) and the Indian Observatories Committee endorsed Kodaikanal due to its superior qualities, including higher altitude.

Planning and Construction

Following official sanction in November 1893, the planning process for the Kodaikanal observatory began in earnest. Michie Smith, now appointed as the permanent Government Astronomer, consulted astronomers in Europe

Kodaikanal Observatory as it appeared in 1908; Charles Michie Smith, founding director of the Observatory.

regarding instrumentation. He also secured the transfer of existing equipment from Madras, including a photoheliograph, spectrograph, and telescopes. By October 1895, the foundation stone was laid by the Governor of Madras.

The construction process faced some hurdles. While the large spectrograph arrived in 1897, it needed temporary housing due to building delays. A disagreement arose between Sir Norman Lockyer and the Astronomer Royal regarding the building plans, leading to a temporary halt in construction. However, the matter was resolved, and work resumed by the end of 1898.

A New Era Begins

April 1st, 1899, marked the official opening of the Kodaikanal Solar Observatory. Although construction continued until December 1901, astronomical work commenced immediately. Efforts were made to shield the observatory from strong winds and beautify the surrounding grounds. The arrival of a specialized spectroheliograph in 1904 further bolstered its capabilities. John Evershed, who joined as Chief Assistant in 1907, would later utilize this instrument in his groundbreaking discoveries.

The establishment of the Kodaikanal Solar Observatory symbolized a significant shift from the broad astronomical pursuits of the Madras Observatory towards a dedicated focus on solar research. This transition paved the way for a new era of scientific exploration in India.

The 6-inch English mounted refractor, acquired in 1850 and remodelled by Grubb in 1898 to serve as photoheliograph, has been acquiring 20 cm white light pictures of the Sun in photographic films on a daily basis for over a century and is functional till today.

3. John Evershed (1864-1956): A Pioneer in Solar Spectroscopy

Early Life and Passion for Astronomy

John Evershed, born in 1864, developed a fascination with astronomy at a young age. He even witnessed a partial solar eclipse at the tender age of 11, using a borrowed telescope. This experience, along with his early interest in solar prominences, fueled his lifelong dedication to solar physics.

Evershed pursued astronomy independently, establishing his own observatory in 1890. He actively participated in various astronomical societies and made significant contributions to the field. His research included studying solar radiation, observing and recording prominences, and experimenting with heated gases and their radiation patterns.‘
Evershed's dedication to solar research caught the attention of renowned astronomers like George Ellery Hale and Sir William Huggins. His expertise ultimately led to his appointment as the Chief Assistant at the newly established Kodaikanal Solar Observatory in 1907.

John Evershed at Kodaikanal Observatory (1907 – 1923)

A picture of John Evershed working on the spectrograph on earlier days of the observatory.

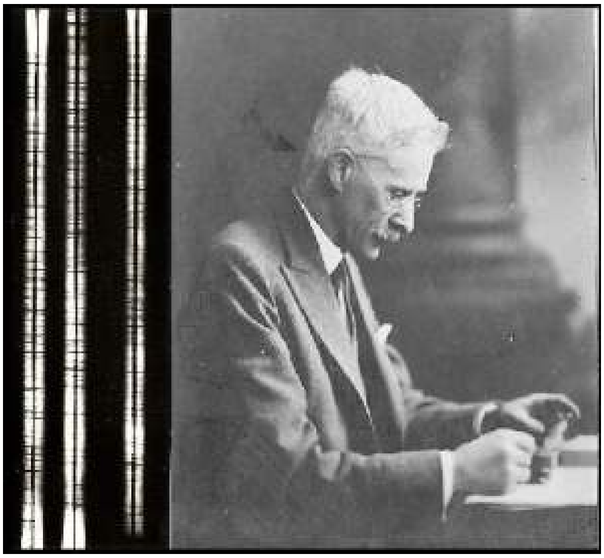
John Evershed arrived at the Kodaikanal Observatory in 1907, not as a novice astronomer, but as a seasoned researcher already renowned for his expertise in solar spectroscopy. His appointment as Chief Assistant was a testament to his dedication to the field, and he immediately set about making significant contributions.

One of Evershed’s initial tasks involved improving the functionality of the newly acquired Cambridge spectroheliograph. This instrument, crucial for capturing detailed images of the Sun’s chromosphere, was not performing to its full potential. Evershed’s meticulous attention to detail and his understanding of the instruments workings proved invaluable in
resolving technical issues and ensuring the spectroheliograph produced high-quality data.

Evershed with KSO Staff

Evershed’s keen eye for celestial phenomena extended
beyond the Sun. He used his expertise to observe both Comet Daniel and Halley’s Comet, contributing to the scientific understanding of their composition through detailed spectroscopic analysis.

However, it is for his groundbreaking discovery in 1909 that Evershed’s name is etched in the annals of solar physics. While meticulously studying sunspot spectra, he observed a remarkable phenomenon: an outward radial flow of gases within these solar features. This discovery, later known as t “Evershed effect”, revolutionized our understanding of the Sun’s dynamic nature and the complex interplay of magnetic fields and plasma flows within sunspots.



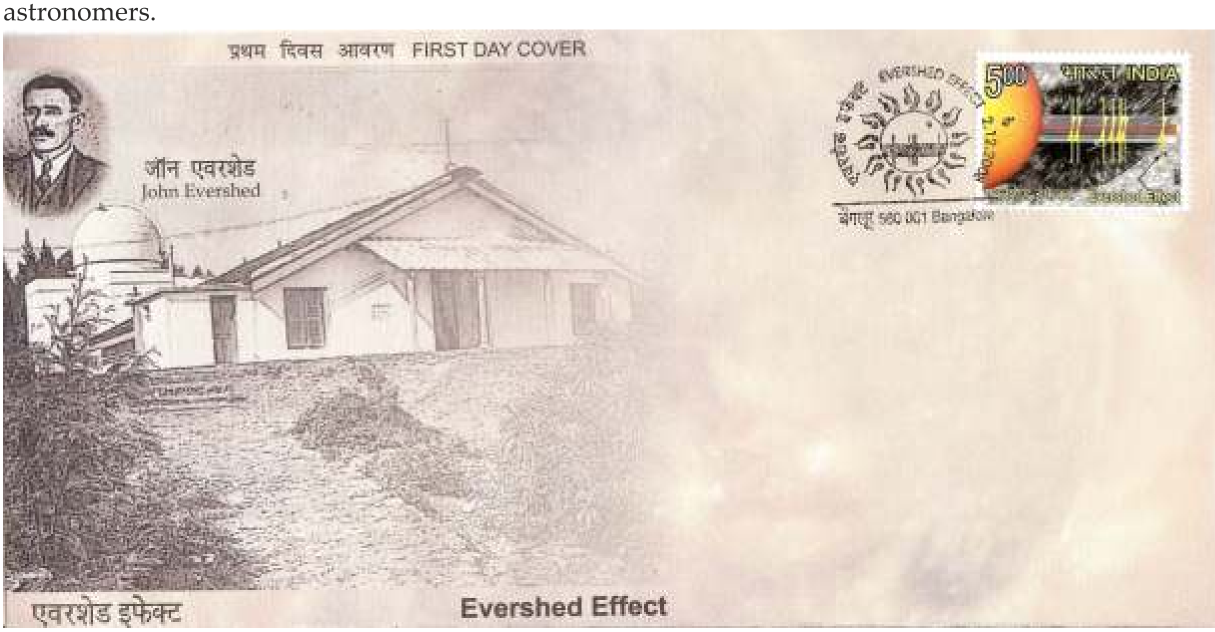
Evershed's dedication to spectroscopic research didn't stop there. He delved deeper into the mystery of the unexplained redshift observed in spectral lines at the Sun's limb. He meticulously measured these subtle shifts, challenging the prevailing interpretation based on pressure variations and paving the way for a more accurate understanding of this phenomenon. His later work on weaker spectral lines even provided supporting evidence for the theory of gravitational redshift proposed by Einstein.

Beyond sunspots, Evershed, along with his wife Mary, maintained a keen interest in studying prominences, the Sun's fascinating tendrils of plasma erupting from its surface. Together, they embarked on a comprehensive analysis of prominence observations, culminating in a significant publication in 1917.

A picture of siderostat light feeding system with mechanical tracking.
A Spectroheliograph capable of making Ca-K and H-alpha image of the sun.

Evershed's dedication to his craft and his keen eye for detail did not go unnoticed. In 1915, he was elected a Fellow of the Royal Society, and in 1918, he received the prestigious Gold Medal of the Royal Astronomical Society, a testament to his outstanding contributions to solar research. Evershed played a pivotal role in establishing Kodaikanal as a leading center for solar research. He actively contributed to spectroscopic work, utilizing existing instruments and designing his own spectroscopes. He also played a crucial role in coordinating international efforts in solar research, collaborating with prominent astronomers like Hale.

After a remarkable tenure at Kodaikanal, marked by groundbreaking discoveries and unwavering dedication, Evershed retired in 1923 and returned to England. However, his passion for solar exploration remained undimmed. He established his own observatory and continued observing the Sun for well over three decades, leaving behind a legacy that continues to inspire generations of astronomers.



To mark the one hundredth anniversary of the discovery of the Evershed Effect, Indian Institute of Astrophysics organised the release of a commemorative stamp and postal cover by India Post on 2 December 2008.

4. Kodaikanal Observatory: A Legacy of Solar Exploration (1923-1960)

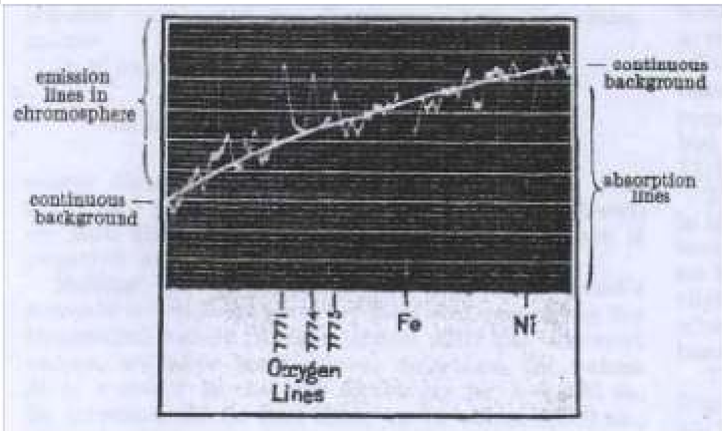
Following John Evershed's retirement in 1923, the Kodaikanal Observatory continued its relentless pursuit of unraveling the mysteries of the Sun. Under the leadership of successive directors, T. Ryods (1923-1937), A. L. Narayan (1937-1946), and A. K. Das (1946-1960), the observatory witnessed a period of significant scientific advancements and instrumental upgrades.

Programmes for international cooperation were established with the Greenwich, Cambridge, Meudon and Mount Wilson observatories, especially to exchange observations for missing days. A Hale spectrohelioscope, received as a gift in 1933 - 34 from the Mount Wilson observatory, set up regular exchanges of observations of the Sun. The Observatory was responsible for communicating to the IAU material for publication of H-alpha flocculi and dark markings, and for the quarterly bulletins of the IAU on solar activity. It also dispatched regular coded messages on solar activity for the benefit of the Meteorological Department, geophysicists, and radio specialists in the country and abroad. The Observatory regularly published the Kodaikanal Observatory Bulletins and also the half-yearly bulletins of solar statistics.

First Independence Day Celebration at KSO

A World-First: Capturing Oxygen Emission Lines

The above era was marked by several groundbreaking discoveries. A remarkable feat was achieved by Royds in 1936 when he successfully captured the first-ever non-eclipse observation of the infra-red triplet of oxygen lines (at wavelengths 7771, 7774, and 7775 Angstroms) as emission lines in the Sun's chromosphere. These lines typically appear as absorption lines, making Royds' observation a groundbreaking discovery. This observation provided valuable insights into the composition and dynamics of the Sun's outer atmosphere.



Royds' observation of oxygen emission lines in the chromosphere recorded as microphotometer scan of the spectrum obtained without the aid of an eclipse.

Observing the Unseen: Deciphering Spectral Shifts

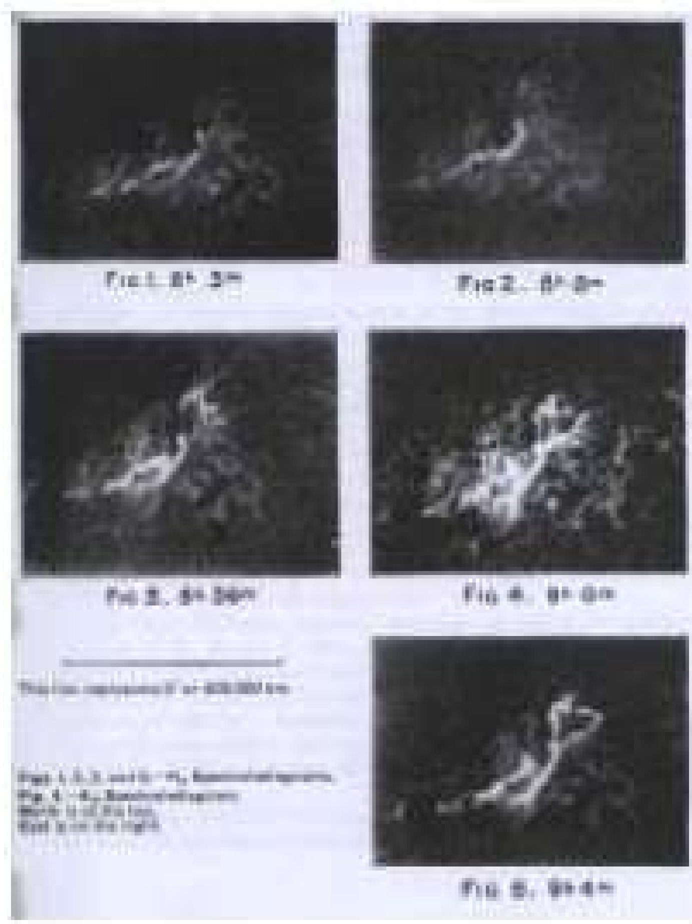
Additionally, scientists at Kodaikanal meticulously studied the variations in hydrogen lines across the solar disk, utilizing this information to probe the structure and properties of the Sun's atmosphere. The Hale spectrohelioscope, along with the main spectroheliograph, was used regularly for observing prominences, dark markings (solar filaments), and for solar flare studies using the Hα spectral lines, leading to detailed investigations on their characteristics.

T. Royds embarked on detailed laboratory studies of spectra, aiming to understand the observed displacements of solar lines compared to terrestrial sources. He, along with A.L. Narayan, further investigated the variations in the strength of several prominent solar lines across the Sun's disc (center to limb variations). This crucial observation provided valuable insights into the Sun's atmospheric structure and composition.

Unveiling Solar Flares: Beyond Established Theories

During a solar flare observation, V.R. Rao and his team simultaneously studied various spectral lines, including Hα, Hβ, and D lines. Their analysis revealed that the observed broadening of these lines was primarily due to the Doppler effect, challenging the prevalent theories attributing it to the Zeeman effect or the Stark effect.

During Royd's tenure, flare patrol and follow-up observations were routine at the observatory. The Royd's flare of Feb. 22, 1926 was an exceptionally strong one recorded extensively with the spectroheliogram (see figure).



Royd's flare of Feb. 22, 1926 covering two large sunspot groups is one of the largest ever recorded at Kodaikanal.

Unveiling the Solar Spectrum: A Chemical Exploration

A.L. Narayan and his colleagues embarked on a comprehensive laboratory study of various atoms, ions, and molecules. By comparing their laboratory findings to the solar spectrum, they successfully identified the presence of P2 and established the existence of CN spectral lines in the Sun. This research significantly enhanced our understanding of the chemical composition of the Sun's atmosphere.

1949 visit of the Astronomical Planning Committee to Kodaikanal Observatory

Eclipse Expeditions

Eclipse expeditions remained an essential aspect of solar research at Kodaikanal. While some expeditions, like those led by Royds to Siam (1929) and Japan (1936), faced adverse weather conditions, others yielded valuable data. Notably, in Japan, Royds successfully employed one of the largest spectrographs ever built at the time to capture the eclipse spectra, becoming the only observer to obtain crucial results. Additionally, Royds conducted crucial measurements of spectral lines at the Sun's extreme limb during these expeditions.

Saha Committee

The year 1945 witnessed the establishment of the Saha Committee by the Indian government. Chaired by the renowned physicist Meghnad Saha, the committee was tasked with formulating a comprehensive plan for the post-war development of astronomical research and education in India. One of the committee's key recommendations focused on enhancing the capabilities for solar observations, particularly during the upcoming first five-year plan. This resulted in the acquisition of critical equipment like a solar tower telescope, a coronagraph, and the establishment of a dedicated laboratory for solar-terrestrial studies at Kodaikanal. By 1960, most of these recommendations had been implemented, solidifying the observatory's position as a leading center for solar research in the region.

The period also saw significant strides in other instrumentations: the establishment of a dedicated ionospheric and geomagnetic laboratory in the mid-1950s marked a crucial step towards comprehensive studies of the Sun-Earth connection. Moreover, the commissioning of the "solar tunnel telescope" in 1960 further bolstered the observatory's observational capabilities.

In conclusion, the period from 1923 to 1960 witnessed the Kodaikanal Observatory flourish into a premier institute for solar research. Through groundbreaking discoveries, instrumental advancements, and continued dedication to eclipse expeditions, the observatory laid the groundwork for future generations of scientists to delve deeper into the secrets of our nearest star.

5. Vainu Bappu and Solar Physics Research at Kodaikanal (1960 – 1982)

M. K. Vainu Bappu arrived in as director of Kodaikanal Observatory in 1960 and by the end of 1962, he put into operation the newly installed solar tunnel telescope. Renewed vigor and productivity characterised solar research in Kodaikanal under the leadership of Bappu.

Vainu Bappu with visitor B.J. Bok and Observatory staff at Kodaikanal in 1962.

By 1965, the tunnel telescope had a spectrograph and a Babcock type magnetograph. There were three spectroheliographs housed in the building adjacent to the solar tower. The hotoheliograph of 20 cm diameter was also in operation.

Solar Tunnel Telescope under construction in 1962

Velocity and Magnetic Fields in the Solar Atmosphere

Arvind Bhatnagar took up detailed spectroscopic studies of the Evershed effect in several Zeeman insensitive spectral lines, along with correlative studies of velocities and brightness fluctuations. These were the earliest such studies of sunspots. K. R. Sivaraman conducted his PhD research studying velocity and intensity oscillations associated with solar 5-minute oscillations during 1966 – 1972. A landmark research activity led by K.R. Sivaraman, in collaboration with Robert Howard of National Solar Observatory (NSO), USA and S.S. Gupta at KSO, concerned the use of several cycles long records of sunspots in white light images at Kodaikanal to study solar surface and internal rotation, sunspot anchor depths, evolution of large bipolar active regions, solar diameter and solar activity cycle related zonal velocity bands.

Beginning 1963, regular observations sunspot magnetic fields were carried out by means of the compound quarter-wave-plate technique and using the 6303 A line. J. C. Bhattacharyya designed and put into use, in 1965, a longitudinal magnetograph of the Babcock type and was in use for the study of weak longitudinal magnetic fields on the solar surface. He also studied the weak field near the polar regions of the Sun.

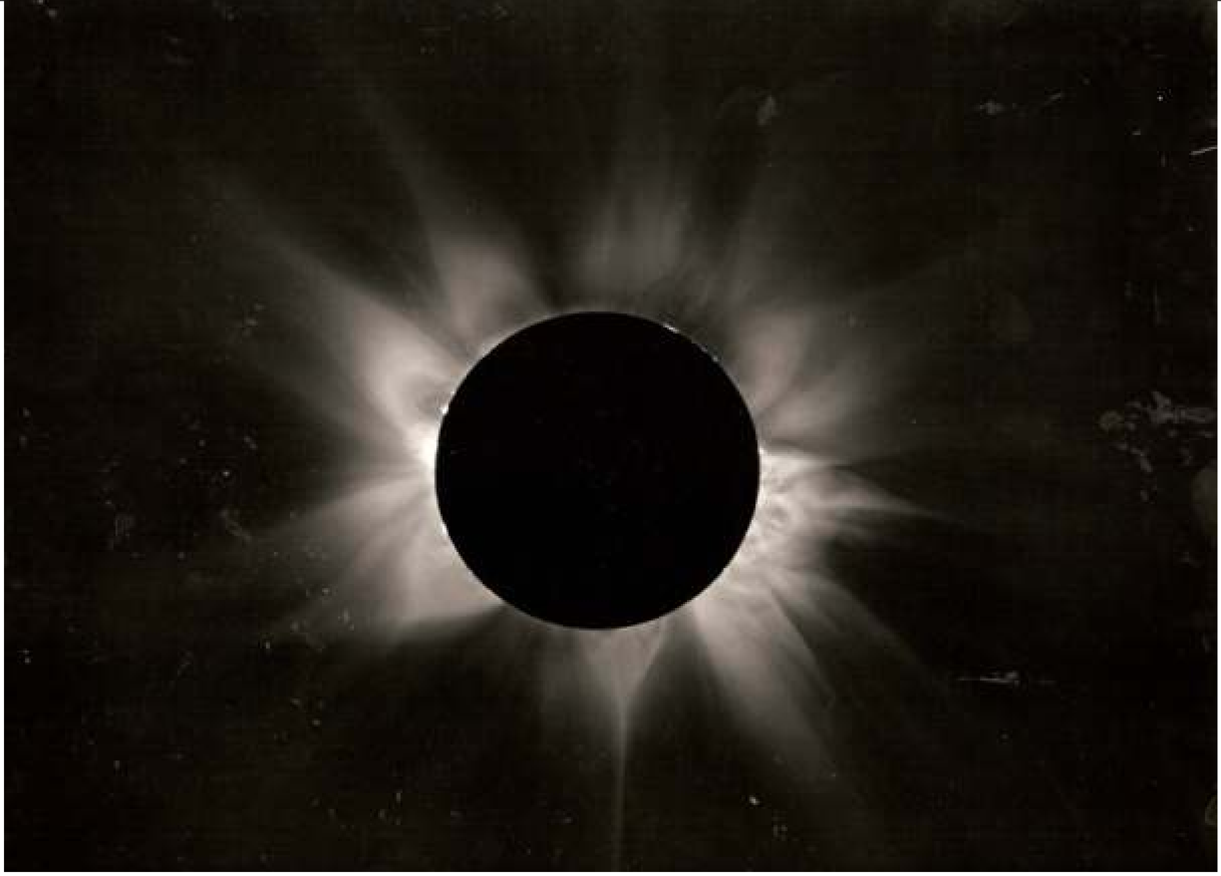
Dynamics of Solar Chromospheric Features

During 1969 – 1976, Bappu and Sivaraman carried out exhaustive studies of the Ca II K line spectra in the context of solar chromospheric activity, solar cycle variations, association between photospheric magnetic structures and Ca II K structures, and the implications of the above for other stars. Sivaraman, Jagdev Singh, Bagare and Gupta, in the mid-1980s, studied the variation of the luminosity of the Sun as a star in Ca II K line. During this same period, Jagdev Singh and co-workers carried out a detailed study of active region contributions to Ca II K line luminosity variations over a solar cycle. Bappu, in 1964, studied intensity fluctuations in the H line due to chromospheric mottling. Singh and Bappu studied the supergranular network size and its variation with solar cycle. Bappu also carried out detailed observations of prominences and calcium occulus. Sivaraman and Makarov observed filament migrations, and poleward migration of magnetic structures, meridional motions, and polarity reversals at the poles.

General View of the Kodaikanal Observatory in 1960

Coronal Studies

Eclipse expeditions to carry out studies of solar corona continued to be a major activity. Bappu, Bhattacharyya, and Sivaraman observed H-alpha and Ca II K lines during the solar eclipse of 1970. Important coronal studies, most notably on coronal wave dynamics, were carried out over several eclipse expeditions starting from 1983 to date. Studies of intensity oscillation in the coronal green line and red emission line were regularly carried out.



Total Solar Eclipse of 1980 captured by IIA team

6. Solar Terrestrial Physics at Kodaikanal: Probing the Sun-Earth Connections

The Solar Terrestrial Physics (STP) facilities at the Indian Institute of Astrophysics (IIA) Kodaikanal Observatory have played a crucial role in studying the Earth's environment for over a century. These facilities provide valuable insights into the interaction between the Sun and our planet.

Ionospheric and Geomagnetic Laboratory: Following India's independence, the Kodaikanal Observatory witnessed a significant development with the establishment of an ionospheric and geomagnetic laboratory. This facility, operational around 1955, marked a crucial step towards understanding the dynamic interplay between the Sun and Earth's environment.

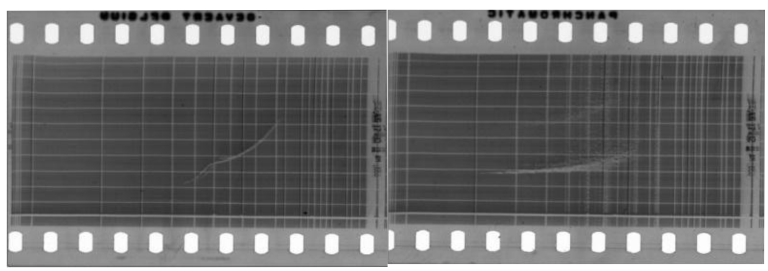
Kodaikanal's geographical position near the geomagnetic equator presented another strategic advantage. The ionosphere, a critical layer for radio communication, exhibits unique characteristics in this region. Studying these phenomena at Kodaikanal offered valuable insights into their behavior and their dependence on solar activity.

The laboratory's research has yielded significant contributions to our understanding of the ionosphere at low equatorial latitudes. Numerous studies have shed light on the processes governing radio wave propagation and its dependence on solar radiation. One noteworthy observation even involved the detection of the geomagnetic effects originating from a distant stellar X-ray source, highlighting the laboratory's sensitivity to subtle influences beyond our solar system.

The establishment of the ionospheric and geomagnetic laboratory marked a pivotal moment in Kodaikanal's journey, solidifying its position as a premier center not only for solar research but also for understanding the intricate connections between the Sun and Earth's dynamic environment.

A glimpse into the past: Kodaikanal Observatory's Ionospheric and Magnetospheric Laboratory

C3–ionosonde



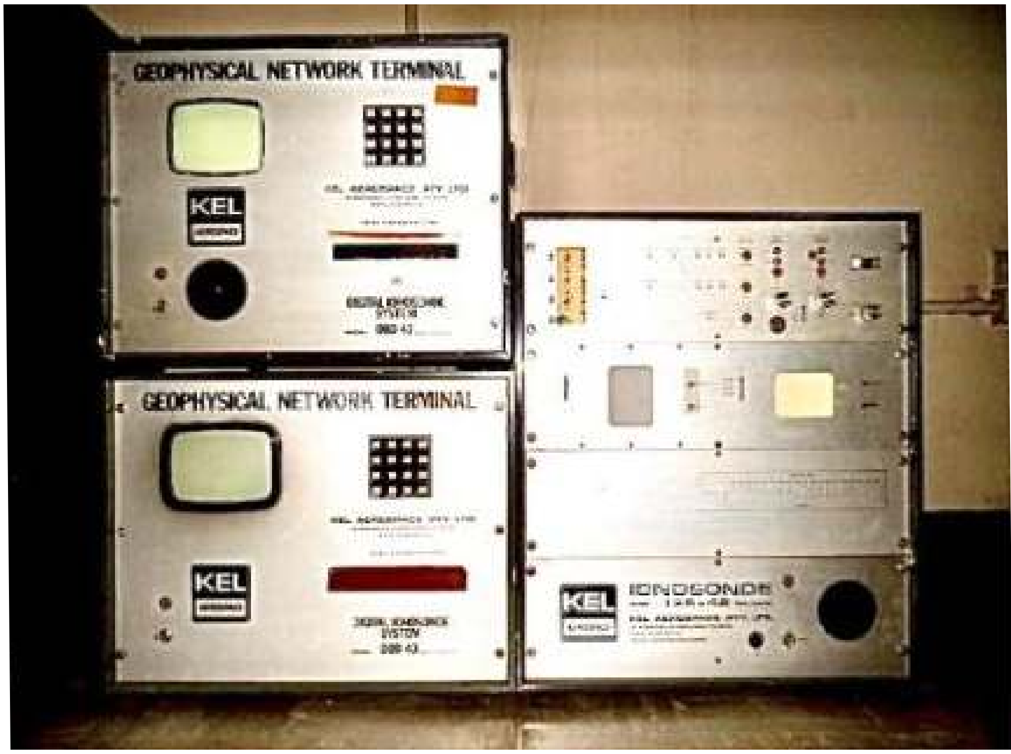
Sample ionograms

La Cour Magnetometer (Early 20th Century): Since the early 1900s, the observatory has employed a La Cour magnetometer, a sophisticated instrument for measuring variations in the Earth's magnetic field. The La Cour system comprises three independent sensors, each equipped with a magnet and a small mirror. Rotations of the mirrors, proportional to changes in the magnetic field components, are captured on a rotating drum using light and photographic paper. This technique creates a continuous visual record, known as a magnetogram, allowing scientists to study the Earth's magnetic activity over time. To ensure accuracy, the instrument's sensitivity is regularly calibrated using Helmholtz coils. These coils generate a precisely calculable magnetic field when a known current is passed through them. By comparing the instrument's response to this controlled field, scientists can adjust its sensitivity for optimal performance.

Photographic recording system

La Cour magnetometer

C3 Ionosonde: (1950 - 1990) Ionosondes send out radio waves and measure the time it takes for them to bounce back from the ionosphere. This allows scientists to map the ionosphere's structure and track its changes throughout the day, season, and solar cycle. In 1952, a C3 analogue ionosonde, installed by the National Bureau of Standards (NBS) at the Kodaikanal Solar Observatory, began collecting data on the ionosphere above India (latitude 10° 13' 50'' N, longitude 77° 28' 07'' E, geomagnetic latitude 0.8° N).



Digital Ionosonde at KSO

Figure displays two typical ionograms, one taken during the day (left) and the other at night (right). These recordings, captured using 35mm film on a C-3 analog ionospheric recorder, show the variations in the ionosphere between day and night. The horizontal axis represents the radio wave frequency (ranging from 1.0 to 20 MHz), while the vertical axis displays the height (up to 1000 km, with markers every 100 km). Scientists use the critical frequencies in the ionograms to understand the ionosphere's behavior. These frequencies, indicated by the highest reflected signals at each layer, correspond to the maximum electron density within those layers.

Researchers can access copies of the original ionogram data on 35mm film.

Proton Precession Magnetometer (1965):
In 1965, B. N. Bhargava and G. A. Viswanathan made a significant breakthrough for ionospheric-magnetospheric research at the Kodaikanal Magnetic Observatory. They designed a portable and user-friendly Proton Precession Magnetometer. This instrument marked a shift towards the use of transistors in scientific equipment, replacing bulkier and less efficient components. Unlike previous instruments, nearly the entire magnetometer was transistorized, except for the signal amplifier. This innovation allowed for a more portable and reliable tool for measuring the Earth's magnetic field.

Digital Ionosonde (1993 - 2001):
In 1993, the Kodaikanal observatory upgraded its ionospheric research capabilities with the installation of a digital ionosonde model IPS 42/DBD43. This new system, commissioned by J. Hanumath Sastri, significantly improved data collection by enabling much faster sounding rates - down to five minutes or even better. The observatory continued to use this advanced equipment for almost eight years, until January 12th, 2001.

Phase path sounder

HF Pulsed Phase Path Sounder (1984 - 2004):
In 1984, the Kodaikanal observatory began using a domestically designed HF pulsed phase path sounder, developed by J. Hanumath Sastri. This instrument provided valuable information about the ionosphere by measuring changes in the "phase path" of radio waves reflecting off different regions at specific frequencies. The data, continuously recorded on a chart recorder, allowed scientists to study variations in the ionosphere with a time resolution of 6 seconds. Data collection continued until 2004.

Legacy and Future:
This well-equipped laboratory is dedicated to understanding how solar activity impacts Earth's ionosphere and geomagnetism. It boasts a unique long-term dataset, continuously gathering ionograms, geomagnetic data, and measurements of vertical drift in the F-region – the longest such collection in the country. The laboratory's location in Kodaikanal offers a distinct advantage: the ability to study the intriguing phenomenon of the equatorial electrojet. Moreover, having solar observation facilities on the same campus allows for even more comprehensive solar-terrestrial research.

7. Kodaikanal's Solar Instrumentation: A Legacy of Observation and Collaboration

The Kodaikanal Observatory has a rich history of instrumental advancements, constantly striving to improve its capabilities for studying the Sun. This dedication to cutting-edge technology is evident in the various instruments acquired and developed throughout the years.

Hale Spectrohelioscope: A Gift for International Collaboration (1933-1934)

In 1933, the Mount Wilson Observatory presented Kodaikanal with a Hale spectrohelioscope, fostering international cooperation in solar observations. This instrument played a crucial role in visually observing the Sun, particularly focusing on prominences, dark markings, and solar flares. The Hα spectral line was used for these observations, and a line shifter device was incorporated to estimate Doppler shifts visually. This valuable instrument remained in operation for the next six decades, serving as a key tool for monitoring transient solar activity. Observations made with the spectrohelioscope often triggered further investigation using the observatory's main spectroheliographs and alerted the on-site ionospheric and geomagnetic laboratory.

The Grubb-Parsons Tunnel Telescope: A Pioneering Facility (1958-1960)

In 1958, Kodaikanal acquired a groundbreaking instrument - the Grubb-Parsons tunnel telescope. Commissioned in 1960, it comprised a 60 cm two-mirror coelostat mounted on a towering structure.

A picture of Solar Tower Tunnel Telescope at Kodaikanal Obseravtory

This innovative design directed sunlight through a series of mirrors and lenses to form a high-resolution solar image at the focal plane. Additionally, the telescope was equipped with a versatile spectrograph and a spectroheliograph, allowing scientists to capture detailed spectra and images of the Sun in specific spectral lines. For nearly half a century, this pioneering telescope remained India's primary facility for high-resolution solar spectroscopy, contributing significantly to our understanding of the Sun's physical processes.

Global Collaboration and Communication

Kodaikanal Observatory has consistently emphasized international collaboration in solar research. They maintained active partnerships with renowned observatories like Greenwich, Cambridge, Meudon, and Mount Wilson, exchanging observations to fill gaps in data collection. Notably, the observatory played a vital role in communicating data on solar activity to the International Astronomical Union (IAU) for publication. They regularly submitted information on Hα flocculi and dark markings, and spectrohelioscope observations were sent for inclusion in the IAU's quarterly bulletins on solar activity.

Furthermore, recognizing the importance of disseminating information within the country, Kodaikanal Observatory initiated a program in 1949 to transmit coded messages on solar activity. These messages served as valuable resources for the Indian Meteorological Department, geophysicists, and radio specialists, keeping them informed about the Sun's dynamic behavior. The observatory also maintained its commitment to publishing its own Kodaikanal Observatory Bulletins and biannual bulletins of solar statistics, ensuring the wider scientific community had access to their crucial solar data.

Kodaikanal's dedication to instrumental advancements and international collaboration has cemented its position as a leading center for solar research. The observatory's legacy continues to inspire future generations of scientists to explore the Sun's mysteries.

Radio Astronomy Facilities at Kodaikanal Observatory (1950 – 1970)

The main focus of the radio astronomy facilities at IIA is on the observations of the Sun. The early observations date back to the 1950s at the Kodaikanal observatory of the institute. Continuous recording of the solar radio noise flux commenced in 1952 using a 100 MHz interferometer with Yagi antennas. A 20 feet paraboloid for observations at frequencies in the decimetre and metre wavelength range was set up on an equatorial mount in 1961. Work on an interferometric aerial for scintillation studies at 60 MHz was also started during this period.

Under the Kodaikanal - Yale Project, recording of radio radiation from Jupiter at a frequency of 22.2 MHz was started using a phase switching interferometer. The custom-built 3 GHz wavelength radio receiver from the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia was put to use in 1965. Mounted on a 2 m paraboloid, it was used for regular solar patrol. In the early 1970s, small-sized antenna arrays operating at 25 MHz were used to obtain information on the radio bursts from the outer solar corona with high temporal and spectral resolution.

The 20 ft dish

The Yagi antenna system

The 3 GHz antenna system in front of the KTT.

The earliest solar observations from KSO in the year 1953 - A. K. Das & B. N. Bhargava, Nature, 1953, 172, 855

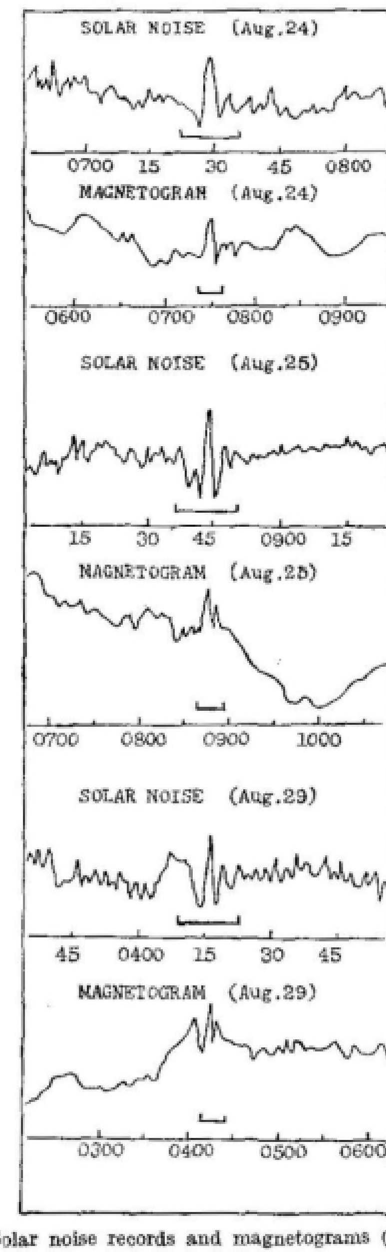


Fig. 1. Solar noise records and magnetograms (times in U.T.)

8. Notable Visitors to Kodaikanal Observatory in Pictures

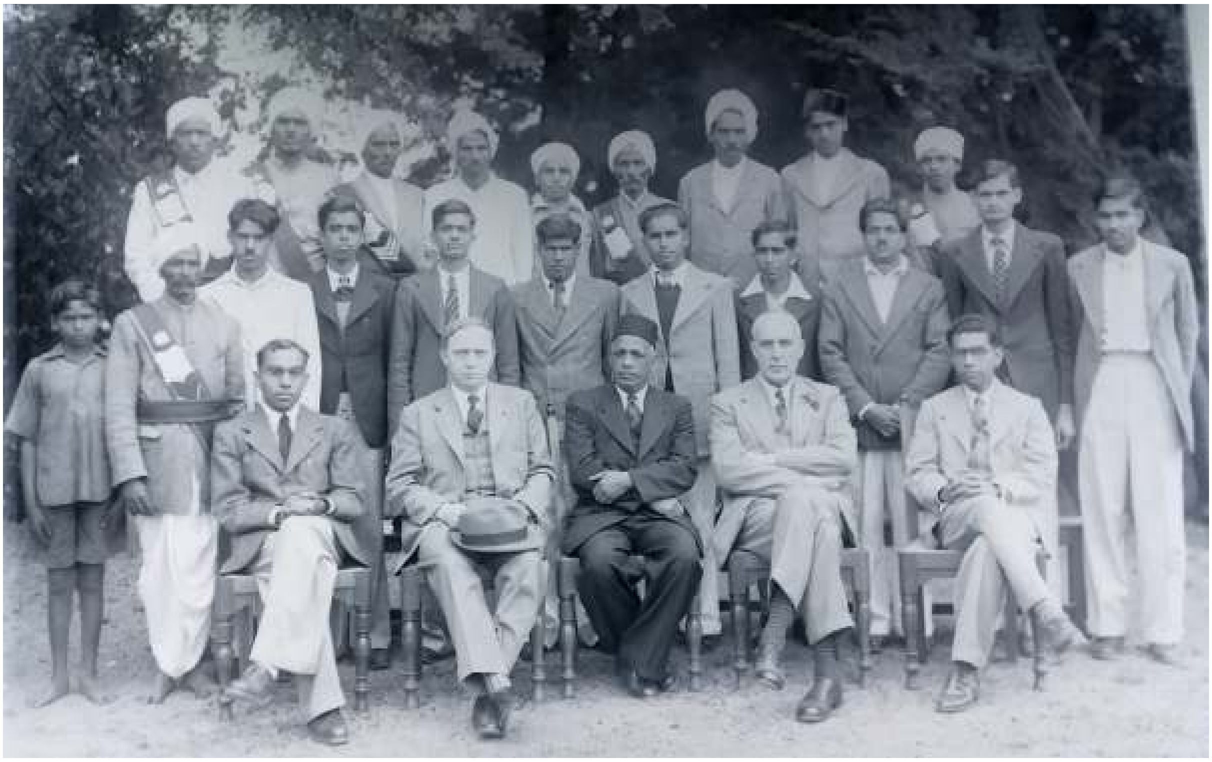


Photo taken in 1947 when the Astronomer Royal visited the Kodaikanal Observatory

Prime Minister Jawaharlal Nehru's visit to Kodaikanal Observatory in 1961

Prime Minister Srimati Indira Gandhi at Kodaikanal Observatory

Prof.S. Chandrasekhar and Lalitha Chandrasekhar's visit to Kodaikanal Observatory, 28 Nov. 1961

9. Unveiling the Sun's Secrets: Current Facilities and Research at Kodaikanal Observatory

The Kodaikanal Observatory continues to be at the forefront of solar research, employing modern instrumentation alongside established techniques. This section delves into the observatory's current observational facilities and ongoing research programs.

Polarimeter instrument is used to measure stokes intensities kept in front of the spectrography. The large white Circle is the sun's image.

Expanding Capabilities: Novel Instruments and Techniques

The observatory's pursuit of innovation is evident in its recent installation of a new, indigenously designed and built spectropolarimeter. This instrument plays a vital role in studying the Sun's active regions, providing valuable insights into their magnetic properties and dynamics.
Additionally, a dedicated system for capturing K-line images using a specialized filter has been operational since 1996-97. This system utilizes a 1K x 1K CCD camera to record the filtered images, offering a complementary perspective on solar activity.

Simultaneous Views of the Sun: The Twin Telescope:

The Twin Telescope comprises two 15-cm Zeiss lenses mounted together, capturing the Sun at different wavelengths. This telescope is functional from February 2008.

Each lens forms a detailed 2.06 cm image of the full solar disk. For white light observations, special filters manage heat and intensity. The Ca-K telescope utilizes similar filters alongside a high-precision filter near the focus to capture exceptionally sharp (0.12 nm) images of the Sun' in Ca-K line. Equipped with two CCD cameras, the telescope allows simultaneous studies of the Sun's photosphere and chromosphere, particularly during active solar events.

Twin Telescope

Understanding the Solar Dynamics with Kodaikanal's New Hα Telescope

Deployed at Kodaikanal Solar Observatory in October 2014, a new Hα telescope unlocks detailed observations of the Sun's dynamic features. Equipped with a 20 cm doublet lens and a tunable Lyot filter with a narrow 0.4 Å bandwidth, the telescope isolates the Hα spectral line. This unique capability allows scientists to observe the Sun at different points within the line, providing valuable insights into various phenomena, including:

Capturing the Sun's Fiery Mood: Kodaikanal's Hα Telescope

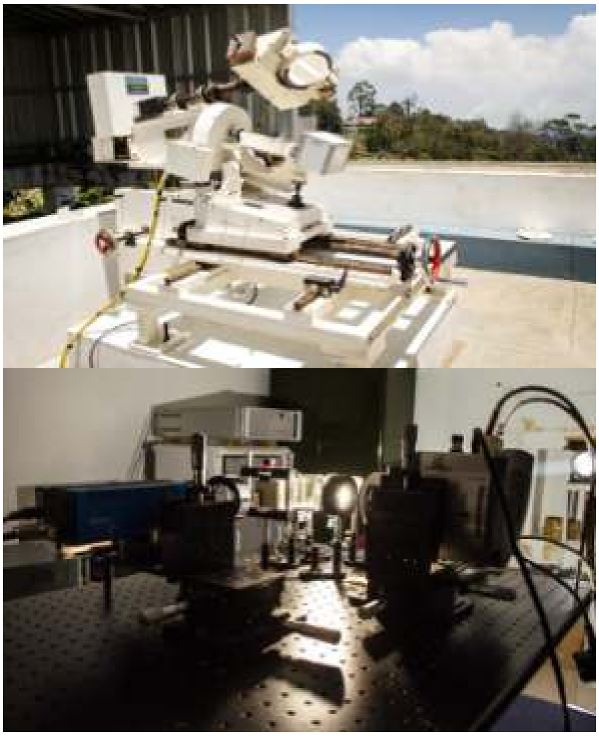
- **Solar filaments:** Studying their internal motions can help us understand the triggers for solar flares and coronal mass ejections.
- **Solar flares:** Precise observations can improve our understanding of their development and potential impacts on Earth's technology and environment.
- **Super penumbra:** Studying these regions can aid in understanding the Sun's internal magnetic field and its influence on solar activity.

Kodaikanal's WARM Telescope: Monitoring the Sun's Layers

The Kodaikanal Observatory, known for its long history of solar observations, has deployed the White Light Active Region Monitor (WARM) telescope since 2015. This instrument delves into the Sun's dynamic layers, capturing the photosphere (outer layer) at a wavelength of 430.5 nm and the chromosphere (middle layer) at 393.3 nm.

Using a unique setup, the telescope employs a two-mirror system called a Coelostat to collect sunlight and direct it to a refracting lens. This light then travels to a platform of specialized instruments for analysis. Additionally, a dedicated system splits the light into two channels, allowing simultaneous observations of the Sun's different layers.

This advanced tool continues Kodaikanal Observatory's legacy of studying the Sun, providing valuable data for understanding solar activity and its potential impact on Earth.



Capturing the Sun's Activity: The White Light Active Region Monitor (WARM) Telescope at Kodaikanal

The Kodaikanal Observatory's current research endeavors span a broad spectrum, encompassing various aspects of the Sun's behavior. These include:

- **Oscillations in the Chromospheric Network:** This research investigates the dynamic nature of the chromospheric network, which is a web-like structure of magnetic fields observed in the Sun's atmosphere.

- **Solar Cycle Variations and Synoptic Observations:** The observatory's long-term observations provide invaluable data for understanding the Sun's 11-year activity cycle and its influence on various solar phenomena.

- **Dynamics of the Solar Corona and Coronal Holes:** Coronal holes are regions in the Sun's outer atmosphere with weaker magnetic fields and lower temperatures. Studying their dynamics helps us understand the solar wind and space weather events.

By continuously modernizing its infrastructure and pursuing diverse research avenues, the Kodaikanal Observatory remains a vital contributor to our understanding of the Sun and its influence on our planet and beyond.

10. Century-old Telescopes and Solar Photographs: Preserving a Century of Sun's History

For over a century, observatories worldwide captured the Sun's image on photographic plates, creating invaluable records of its activity. However, these traditional formats posed limitations for modern research due to the difficulty of extracting information. To address this, many observatories, including the Kodaikanal Solar Observatory embarked on digitizing their archives.

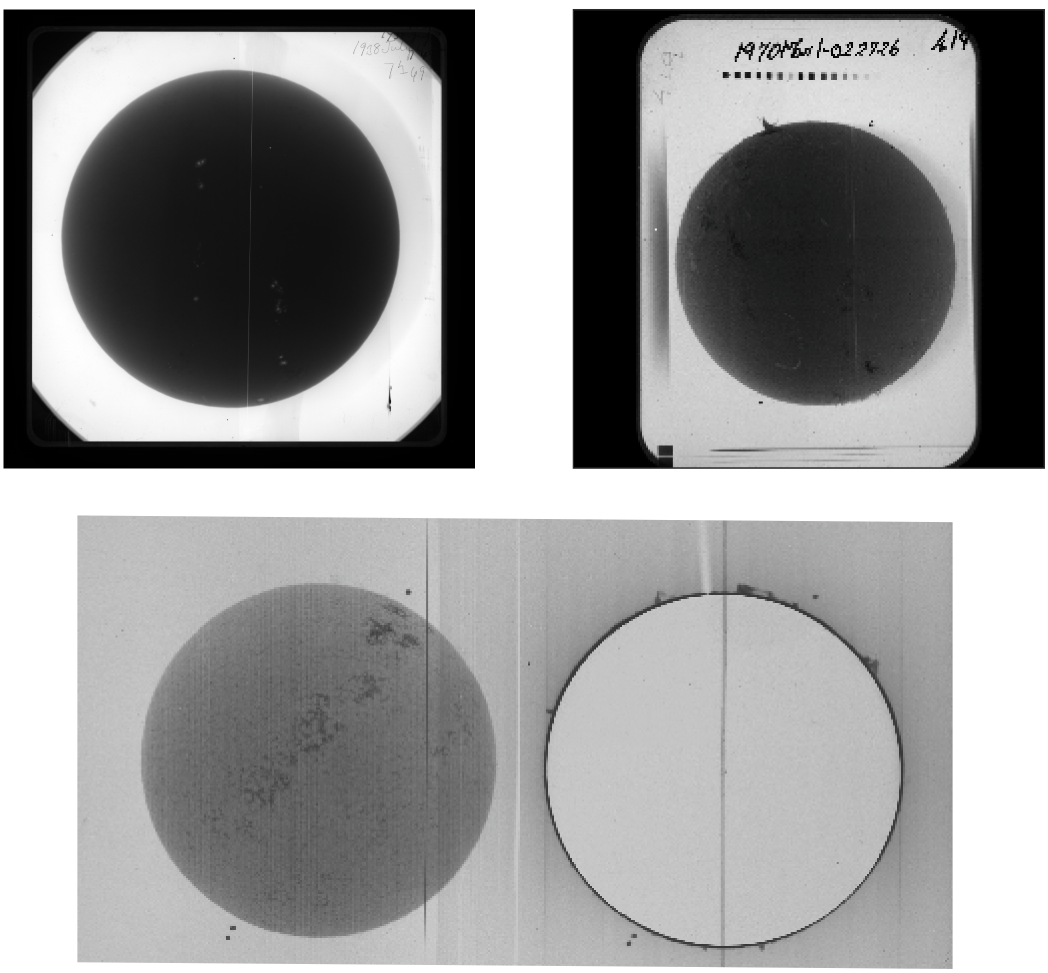
Kodaikanal Observatory has a unique collection of solar images captured in three wavelengths: Ca II K, Hα, and white-light, all originally stored on photographic plates. Notably, the white-light data boasts uninterrupted capture for over a century using the same telescope, ensuring consistency and minimizing instrumental variations. This consistency also allows valuable overlap with newer data collected using different instruments at Kodaikanal.

Recognizing the immense scientific value of this long-term dataset, an initial digitization effort was undertaken in the past using a CalComp digitizer to record the position of sunspots and the solar limb. However, this process did not capture the actual solar images.

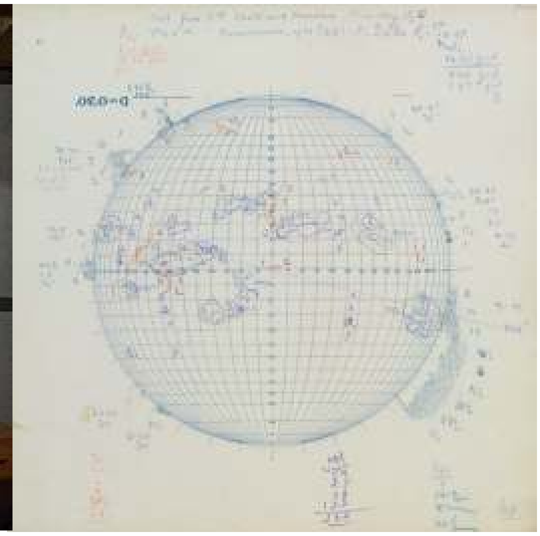
Digitization of Kodaikanal Data Archives: From Plates to Pixels

A digitizer unit at KSO

This initiative involves a new digitizer equipped with a high-resolution CCD camera and a uniform light source. wo identical digitizer units were utilized to efficiently process the vast collection of photographic plates. The photographic plates were illuminated by the uniform light source, and their images were captured with varying exposure times (5-30 seconds) depending on their transparency. This state-of-the-art equipment allows for capturing solar images with superior spatial resolution (1 arcsecond), improved limiting resolution, and exceptional photometric accuracy.



Digitised photographic plates taken in White-light, H-alpha and Ca-II K wavelengths



Zeutschel - OS 12002 scanner **Solar Drawing from KSO**

These digitized images are now available online, providing researchers with a wealth of information for exploring the Sun's activity over the past century. The users can access the data at https://kso.iiap.res.in/. Furthermore, a search engine developed in-house facilitates the exploration of daily images spanning the entire observation period (1904-present) in both raw and calibrated formats. Finally, the observatory plans to make full-resolution FITS images available through the same web portal in the near future, providing researchers with comprehensive access to this invaluable data collection.

This project not only safeguards a century of solar observations but also unlocks them for future generations of scientists, enabling new discoveries and a deeper understanding of our star.

11. Celebrating 125 Years of the Kodaikanal Solar Observatory: A Legacy of Light and Learning

The Kodaikanal Solar Observatory, nestled amidst the scenic hills of southern India, marks its 125th anniversary this year. This momentous occasion presents a unique opportunity to not only celebrate the observatory's rich history and groundbreaking contributions to solar science but also to recognize the enduring significance of its mission.

A Pioneering Legacy: Illuminating the Sun's Secrets

Established in 1899, the observatory stands as a testament to the unwavering human quest to understand the Sun, our closest star. Pioneering figures like John Evershed laid the foundation for solar research at Kodaikanal, developing innovative techniques like spectrohelioscopy to study the Sun's dynamic chromosphere and sunspots. These early efforts not only yielded crucial insights into the Sun's behavior but also paved the way for generations of scientists to come.

Beyond Discovery: Unraveling the Sun-Earth Connection

The observatory's journey transcended mere observation. The establishment of the ionospheric and geomagnetic laboratory marked a significant milestone in understanding the intricate connection between the Sun's activity and its impact on Earth's ionosphere and magnetic field. This crucial knowledge has proven invaluable in various fields, including space weather forecasting, satellite communication, and protecting power grids from geomagnetic storms.

A Global Collaborator: Fostering International Understanding

Kodaikanal Observatory has consistently strived for international collaboration, recognizing the importance of collective knowledge and data sharing in advancing solar science. Throughout its history, it has actively exchanged data with renowned observatories worldwide, fostering a spirit of scientific exchange and collaboration that continues to benefit researchers across the globe.

Shaping the Future: Inspiring the Next Generation

The observatory's commitment to innovation extends beyond its historical achievements. The recent installation of cutting-edge instruments like the spectropolarimeter and ongoing digitization projects demonstrate its unwavering dedication to employing the latest technologies to further our understanding of the Sun. This commitment to continuous improvement serves as an inspiration to budding scientists and engineers, shaping the future of solar research and exploration.

Celebrating 125 Years: A Beacon of Light for the Future

Celebrating 125 years of the Kodaikanal Solar Observatory is not just about commemorating the past; it is about recognizing the enduring value of its contributions to science, technology, and our collective understanding of the universe. The observatory's legacy serves as a beacon of light, inspiring future generations to explore the unknown, foster international collaboration, and continue unraveling the mysteries that lie within our closest star. By celebrating this anniversary, we acknowledge the observatory's vital role in shaping our scientific understanding of the Sun and its profound influence on our planet and beyond.

PhD Theses from the Kodaikanal Solar Observatory

The Kodaikanal Observatory's data has demonstrably influenced solar physics research in India. Numerous Ph.D. theses, a substantial volume of scientific publications, and countless student projects have all drawn upon this valuable resource. Due to space limitations, this document cannot provide an exhaustive list. However, the following Ph.D. theses exemplify studies that significantly benefitted from KSO data.

1. Bhatnagar A. 1964: The Evershed effect in sunspots, Supervisor: M. K. V. Bappu

2. Nirupama, S. 1965: High dispersion spectroscopy of molecules in the solar atmosphere, Supervisor: M. K. V. Bappu

3. Ganesh K. S. 1966: Spectrographic study of Wolf-rayet stars, Supervisor: M. K. V. Bappu

4. Bhattacharyya J. C. 1969: Studies of solar magnetic and velocity fields.

5. Sivaraman K. R. 1972: Velocity oscillations in the solar atmosphere, Supervisor: M. K. V. Bappu

6. Balasubramaniam K. S. 1988: Stokes polarimetery and the measurement of vector magnetic fields in solar active regions, Supervisor: J. C. Battacharyya

7. Srikanth R. 1998: Studies on solar chromospheric network, Supervisor: Jagdev Singh and Som Krishan

8. Sankarasubramanian K. 2000: Solar polarimetry: techniques and applications, Supervisor: P. Venkarakrishnan

9. Javaraiah J. 2000: Study of solar rotation and solar activity, Supervisor: M. H. Gokhale

10. Sridharan R. 2001: Techniques for achieving higher spatial resolution

11. Nagaraju K. 2008: Spectropolarimetry of active regions on the sun, Supervisor: K. E. Rangarajan

12. Sindhuja G. 2015: Study of solar chromosphere: Variation of Ca-K line profiles with solar cycle.

13. Subhamoy Chatterjee 2019: Characterizing image quality of solar unltraviolet imaging telescope onboard Aditya L1 mission and long-term study of the sun, Supervisor: Dipankar Banerjee

14. Hemath Pruthvi 2019: Design and development of chromospheric vector magnetograph for sunspot studies, Supervisor: Ravindra B

15. Muthu Priyal 2020: Study of solar chromosphere variations on the sun using Ca-K line images during 20th century, Supervisor: Chandar Shekar B

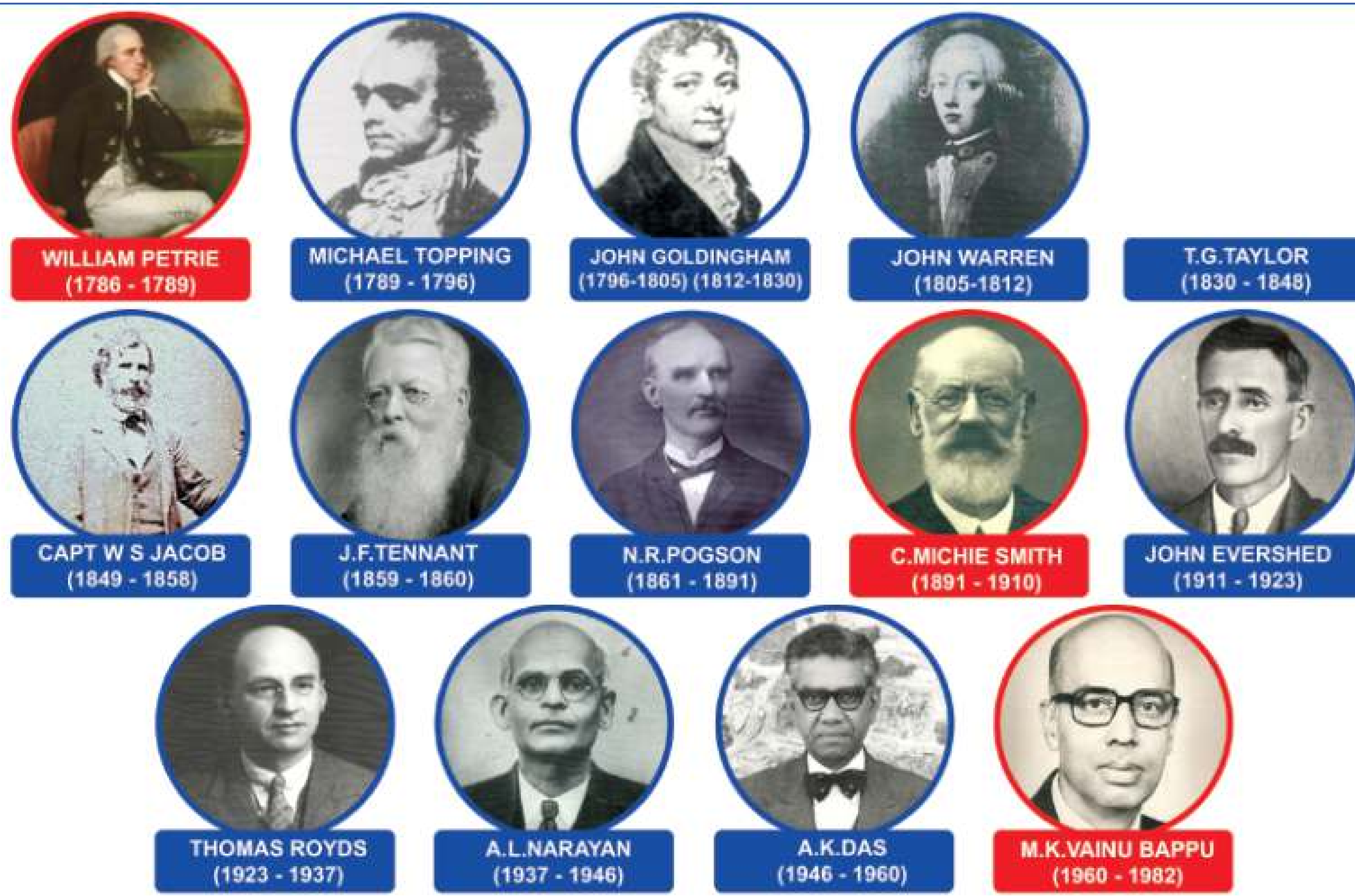
16. Bibhuti Kumar Jha 2022: Long-term study of the Sun and its implications to solar dynamo models, Supervisor: Dipankar Banerjee

References:

1.“Solar physics at the Kodaikanal Observatory: a historical perspective”, S.S. Hasan, DCV Mallik, S.P. Bagare, and S.P. Rajaguru 2010, Proc. Of “Magnetic Coupling between the Interior and Atmosphere of the Sun”, Springer Berlin Heidelberg, p.12 – 36.

2.The Evershed Brochure, 2010, Published by the IIA

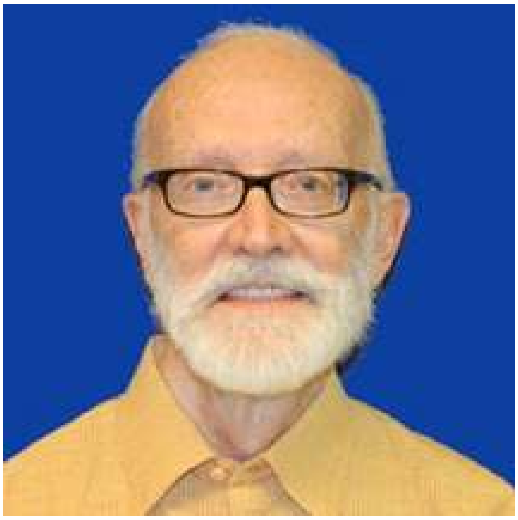
3.“Colonial Astronomy as an Element of Empire in British India”, R.C. Kapoor and Wayne Orchiston, 2023, Journal of Astr. Heritage and History, 26(1), 113.



Past Directors of Kodaikanal Solar Observatory

Dr. John Leibacher

Former Director, National Solar Observatory, USA



Greetings Ravindra, Rajaguru, Professor Subramanian, friends and colleagues, distinguished guests

I am delighted, and honored, to be invited to contribute a few words on the occasion of your celebration of the 125 years of science and public engagement at the world famous Kodaikanal Solar Observatory

Maybe I should introduce myself/provide my credentials, briefly first: I was for many years director of the US National Solar Observatory at Sac Peak and Kitt Peak, and director of the Global Oscillation Network Group (GONG), and more recently have been Editor-in-Chief of the journal Solar Physics for nearly 20 years. I have had the pleasure of visiting the IIA on a number of occasions over nearly 40 years, and Kodaikanal back in 1999 at a very memorable conference, the very last International Astronomical Union Colloquium of the 20th century, organized by Venkatakrishnan, Choudhuri, and Engvold, I believe. I have enjoyed meeting with the Governing Council, and most recently serving as a member of the IIA's Scientific Advisory Committee. So, I hope that these brief comments are informed.

We all know the proud history and significance of Kodaikanal, but I must admit to my interest and pleasure in rereading the very nice and authoritative history written by Siraj Hasan and colleagues for the centenary of the discovery of the Evershed effect – I recommend it. My first real introduction to Kodai was through the work of my colleague Bob Howard with K. Sivaraman and Jagdev Singh on the fabulous collection of sunspot data at Kodai. I applaud the work on making the Digital Archive of this data easily available online to the entire world. It will surely enhance the scientific output of the past and future use of Kodai.

But this is a celebration, not just a retrospective, and in this age of high spatial resolution solar observations from the ground and observations from space above the Earth's atmosphere in the UV and X-rays, Kodaikanal has a continuing essential and complementary role to play in instrumentation development and training the next generation of solar physicists and instrumentalists, in addition to its traditional roles, with Aditya-L1 coming online (congratulations!!) and NLST, which should start construction very soon. Kodai provides the whole Sun, macroscopic view of large-scale solar and stellar processes: magnetic activity, dynamos, meridional circulation, and on and on.

Please permit me to conclude by going off-topic for just a moment. We, in the world-wide solar physics community, are all looking forward more than eagerly to India and NLST's taking its place as a premier high-resolution facility for the investigation of the small-scale physical processes that control the Sun's atmosphere, and thus stellar atmospheres. While DKIST (the Daniel K. Inoue Solar Telescope in Hawaii) has just come on-line, and is working spectacularly well, and hopefully the planned European Solar Telescope (in the Canary Islands) will join it someday, NLST's unmatched and complementary capabilities at Pangong Lake (Merak), located 120 degrees in longitude away from these, will offer unmatched opportunities to the Indian and international solar physics community and continue the long and proud heritage of Indian leadership in solar physics.

Best wishes to KSO and all of you there at Kodai, and many happy returns,

Namaste

Danyvaad, Shukria

Prof. Alexie Pevtsov
Associate Director,
National Solar Observatory, USA

Dear Colleagues,

I am sending my hearty congratulations with the 125th anniversary of the Kodaikanal Solar Observatory.

The Observatory made significant contribution to the field of solar astronomy including discovery of several fundamental processes such as the Evershed effect. Perhaps the most important contribution, however, is the historical synoptic photographic observations of solar activity taken in CaK , H-alpha spectral lines and a broadband (white light). This data provide continuous record of solar activity for over the last century, and enable new discoveries about our nearest star and its cyclic activity.

While modern solar physics puts an emphasis on achieving extremely high spatial resolution, synoptic observations remain to be critical for understanding of evolutionary and cyclic changes in solar activity and its impact on space weather and space climate. I thank the Observatory staff for their tireless effort in preservation, digitization, and scientific exploration of these historical records.

Again, congratulations with the 125th anniversary of the Kodaikanal Solar Observatory.

With my warmest regards,

Flora & Fauna at Kodaikanal Solar Observatory

Malabar giant squirrel

Bison

Attacus atlas (The Atlas mouh)

White bellied sholakili

Nilgiri flycatcher

Eurasian hoopoe

Rock eagle owl
(Indian eagle owl)

Red-whiskered bulbul

Photo Credits : M N Anand


Celebrating 125 Years
Kodaikanal Solar Observatory
Since 1899