# The Solar Physics Observatory at Kodaikanal and John Evershed

*D C V Mallik*

**The Kodaikanal Observatory was established during the closing years of the 19th century to carry out scientific observations of the Sun. John Evershed, an established amateur solar observer, came to Kodaikanal in 1907 as the Chief Assistant to the Director and became the director of the observatory 4 years later. In 1909, he discovered the phenomenon of radial motion of gases in sun spots, the earliest successful observation of velocity fields due to a complex magnetohydrodynamical process in action in a celestial setting. Through Evershed's work Kodaikanal became known as one of the premier solar observatories in the world.**

D C V Mallik, an astronomer by training, formally retired from the Indian Institute of Astrophysics, Bangalore three years ago but is still affiliated to IIA in a visiting capacity. His professional research has been mainly in the area of Interstellar Matter and Astrophysics of Nebulae. He was an Associate Editor of *Resonance* from September 2001 to December 2004.

For some years now, Mallik has been interested in History of Science and is currently engaged in a historical study of Jewish scientists in exile in India.

**Keywords**

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## Introduction

More than two hundred and twenty years ago, an observatory was started in Madras by the East India Company "for promoting the knowledge of astronomy, geography and navigation in India". The observatory grew in the 19th century to be one of the principal institutions devoted to work on the fundamental positions of stars, and until the commencement of activity by the British at the Cape Observatory in South Africa, the Madras Observatory continued to be a principal source of stellar positions for most of the southern hemisphere stars.

Norman Pogson, a distinguished stellar and planetary astronomer, whose name is associated with the modern definition of the stellar magnitude scale, was the Director of the Madras Observatory for 30 long years from 1861 to 1891. The observatory had acquired a transit circle by Troughton and Simms which was mounted and ready for use in 1862. Pogson, who had considerable experience with transit instruments in England, put this instrument to good use. With the help of his Indian assistants, Pogson measured accurate positions of about 50,000 stars for the next 25 years. In addition to his routine work, Pogson used an 8-inch Cooke equatorial to observe asteroids and variable stars. He discovered quite a few new objects.

Apart from his own accomplishments in astronomy, Pogson's years in Madras are remembered for another important reason – two total eclipses and one annular eclipse of the Sun were visible from India during the period, to all three of which Pogson led teams from his observatory taking an active part in the events. The first one of these, a total eclipse on August 18, 1868, excited an enormous interest amongst European astronomers and preparations for its observation were made in England and France for many months preceding the event. Teams of professional astronomers from both countries arrived in India and established their camps at Guntoor, on the central line of the eclipse. The Madras Observatory astronomers had their camp further east at Masulipatam and Vunpurthy, in the territory ruled by the Nizam of Hyderabad.

This eclipse is of great historical significance as it was the first time that spectroscopes were used during an eclipse event. Spectroscopy of the flash spectrum led to the discovery of a new line close to the $D_2$ line of sodium, which could not be assigned to any known chemical element and in turn, led to the discovery of a new element, named Helium after the Sun. During the same eclipse, observations of the hydrogen Balmer lines in the spectra of the prominences established their gaseous nature.

Historically, the eclipse of 1868 marks the beginning of solar physics. Janssen and Lockyer made effective use of the spectrograph to show that 'red prominences could at any time be examined, without waiting for an eclipse at all'. During the annular eclipse of 1872, Pogson found the bright chromospheric spectrum flash out for a short duration on the formation and again at the breaking up of the annulus. This is the first observation on record of viewing the flash spectrum at an annular eclipse.

**Establishment of a Solar Physics Observatory**

In 1879, a committee was appointed by the British Government, consisting of the leading astronomers in Britain to consider and advise on the methods of carrying on observations in solar physics. One of the tasks of the Solar Physics Committee (hereafter SPC) was to reduce the solar photographs which were being taken daily since 1878 with a photoheliograph in Dehra Dun. The Government of India had supported the work in the belief that a study of the Sun would help in the prediction of the monsoons, their success and failure, the latter often leading to famines that caused such a havoc. SPC also suggested to the Surveyor-General, Government of India 'that photographs of the Sun should be taken frequently in order that India might assist towards securing a permanent record of the number and magnitude of the sun's spots and other

*Figure 1. A view of the Kodaikanal Observatory,1905.*

changes in the solar surface'. SPC was aware that the number of sunshine hours in India was far greater than anywhere in the British Isles. At a later date SPC added that special spectroscopic observations should also be undertaken in India.

In 1885, The Royal Society, London, constituted an Indian Observatories Committee with the Astronomer Royal in chair, which was entrusted with the task of coordinating the work of Madras and Bombay Observatories and of advising the Secretary of State for India regarding the administration of these observatories. The suggestions of the Solar Physics Committee on regular observations of the Sun and the thinking of the Indian Observatories Committee on the future orientation of activities of the Madras Observatory converged to pave the way for the creation of a new observatory in the hills of South India. After the death of Norman Pogson on June 23, 1891, a series of initiatives were taken that eventually led to the establishment of the Solar Physics Observatory in Kodaikanal. Officially, the observatory started work on April 1, 1899. All major astronomical equipment and the library were shifted from Madras to Kodaikanal and new instruments for specific observations of the Sun were ordered.

John Evershed joined Kodaikanal Observatory as the Chief Assistant to the Director on January 21, 1907. The then Director, Michie Smith, went on long leave soon after. Evershed had to take charge of the observatory almost as soon as he arrived. On Michie Smith's retirement in 1911, Evershed became the Director and he remained in Kodaikanal till 1923. The sixteen years that John Evershed spent at Kodaikanal are remembered today as the Golden Period of the Kodaikanal Observatory.

**John Evershed (1864–1956)**

John Evershed was born at Gomshall in Surrey on February 26, 1864. Evershed's interest in astronomy began rather early. When he was six, his imagination was stirred by looking at a magazine picture of German shells falling in the streets of Paris in 1868, during which Janssen, the French astronomer, escaped by balloon from the besieged city to watch the total eclipse of the Sun. When he was only 11, there was a partial eclipse of the Sun, visible from Surrey, and boy Evershed ran almost all the way from Gomshall to the neighbouring Shere to watch the eclipse through a telescope belonging to a doctor. Evershed was educated at a preparatory school at Brighton. He then went to a school at Croydon. In 1877, at the age of 13, he constructed a telescope with some odd lenses and watched Mars, which was near opposition then, with the telescope, but through a plate glass window sitting inside a room, as he was told that the night-air was harmful for children. No wonder he became a solar astronomer!

Evershed's eldest brother, Sydney Evershed, was a student at the School of Mines in London and was good with his hands. Sydney had notable scientific attainments later – he had invented an electrical apparatus, built electrical measuring instruments for the Navy and carried out research in magnetism. Evershed's early training in building instruments and at workshop practice were received from his brother. He built his first spectroscope with a tiny prism of 1 cm aperture given to him by Sydney and a pair of lenses from a disused opera glass. He was able to see the Fraunhofer spectrum of the Sun quite satisfactorily, even the fine structure of the sodium lines, but the instrument was hopeless for viewing prominence spectra. Evershed was deeply influenced by the publications of Sir Norman Lockyer in *Nature* which he read with great interest. He built a spectroscope in the same design as Lockyer's with a train of prisms and with this attached to a 3-inch telescope he obtained beautiful views of the prominences. Evershed was trained as a chemical engineer and took up jobs as an industrial chemist in various manufacturing concerns. Outside of his work, he was an avid amateur astronomer and viewing the Sun and solar prominences was his real passion.

In 1890, Evershed set up a private observatory in Kenley, Surrey, and with the spectroscope he had designed, and his 3-inch telescope, he started a long series of observations of prominences and recorded their distribution in heliographic latitude and their variation with the cycle of sun spots. In the spring of 1891, George Ellery Hale in Chicago invented the spectroheliograph. Using the spectroheliograph and a 12-inch telescope, Hale was soon able to see the chromospheric reversals in the Ca II H and K lines. Evershed had his own way of photographing prominences in the H-beta line of hydrogen. With this technique of monochromatic photography, he was getting solar images showing the brilliant flocculi around sun spots. When he learnt about Hale's new machine, he abandoned the idea of working in the hydrogen line and transferred his attention to the Ca II K line that Hale was using.

Through some correspondence in the journal *Knowledge*, Evershed got to know Arthur Cowper Ranyard, a barrister by profession but with a deep interest in astronomy, who was the editor of *Knowledge*. Ranyard knew Hale personally. When Hale visited England in 1894, Ranyard introduced Evershed to Hale. This was the beginning of a long friendship between the two ace solar astronomers of the time, which lasted till Hale's death in 1938. Ranyard died in 1894 and left Evershed with his 18-inch reflecting telescope and a small spectroheliograph. Evershed found problems with Ranyard's machine. He mounted the 18-inch telescope at Kenley, and designed a spectroheliograph of his own using large direct vision prisms, which had none of the problems of Ranyard's machine. Hale is supposed to have remarked that Evershed was the only other person besides himself to have (independently) built a spectroheliograph.

Evershed's first visit to India was in connection with the eclipse of January 22, 1898. He obtained excellent flash spectra and caught the emission continuum at the head of the Balmer series (shortward of 3646 Å) extending to the ultraviolet end of the plate. He realised this was the counterpart of the continuous absorption spectrum seen by William Huggins in stars with strong hydrogen absorption lines. At a later solar eclipse in Algeria in 1900, he repeated the same experiment and again saw the continuum emission. His results definitively proved that the flash spectrum and the Fraunhofer spectrum were of the same origin, the flash spectrum representing the higher and more diffused portion of the gases which, under normal circumstances, produced the Fraunhofer spectrum by absorption of the underlying continuum. At all eclipses, Evershed carried his own home-made instruments, prismatic spectroscopes with a long focal length camera, where only the optical parts were procured from specialised manufacturers.

The results of Evershed's eclipse expeditions attracted the attention of the great spectroscopist Sir William Huggins who was then the President of The Royal Society. So, in 1904, when the Government of India sanctioned the appointment of an European Assistant to Michie Smith, Director of the Kodaikanal Obsrvatory, Huggins strongly recommended John Evershed for the position. When Evershed received the offer, he was a bit depressed at the prospect of having to close down his private observatory in Kenley. He also had to make sure that his fiancée would not mind going to India. He was engaged to be married to Mary Ackworth Orr, a young and sprightly amateur astronomer and a member of the British Astronomical Association, who he had first met at the eclipse expedition of August 9, 1896 in Norway. Their common interest in astronomy had drawn them close to each other. In September 1906, John and Mary got married and they left for India soon after.

On the advice of Professor Turner of Oxford, the Eversheds decided to take the longer route to India via America and Japan. Turner gave Evershed introductions to the leading American astronomers of the day, Pickering in Harvard, Frost at Yerkes and Barnard and Campbell at Lick. Evershed's main aim, of course, was to spend a month with Hale at Mt Wilson. The Eversheds arrived in Pasadena on October 18 planning to spend a full month with Hale. However, owing to some mis-communication Hale was away at the time. But the couple had a wonderful and scientifically fruitful time organised by Hale's main solar collaborator Ellerman and the staff of Mt Wilson. Evershed was deeply impressed by the instruments, and the method of work at

Mt Wilson. On January 21, 1907 the Eversheds reached Kodaikanal. This was his first professional appointment as an astronomer.

**Evershed in Kodaikanal: Discovery of the Evershed Effect**

The principal thrust of the work at Kodaikanal was solar spectroscopy. In 1902, a Cacium-K spectroheliograph had been ordered from the Cambridge Scientific Instrument Company and it had arrived in Kodaikanal in 1904. Evershed got his hands dirty as soon as he arrived in Kodaikanal. With his expertise and experience he was soon able to put the Cambridge Spectroheliograph into fully efficient operation. He also started working on an auxiliary spectroheliograph to obtain pictures of the Sun in H-alpha.

Evershed's chief work in the initial years in Kodaikanal was on the spectra of sun spots. He used the high dispersion spectrographs at the observatory (there were two of them) to systematically study the spectra of spots whenever the weather was favourable. In the early morning of January 5, 1909, on a day when the atmosphere was exceptionally steady and the sky transparency was excellent after some heavy thunderstorm activity, Evershed found two large spots and obtained their spectra. As he says, 'the spectra revealed a curious twist in the lines crossing the spots which I at once thought must indicate a rotation of gases, as required by Hale's recent discovery of strong magnetic fields in spots, but it soon turned out from spectra taken with the slit placed at different angles across a spot that the displacement of the lines, if attributed to motion, could only be due to a radial accelerating motion outward from the centre to the umbra. Later photographs of the Calcium H and K lines and the H-alpha line revealed a contrary or inward motion at the higher levels represented by these lines.' This was the first time line displacements in the penumbral region were seen indicating an outward radial flow of gases in the spots. None of the previous spectroscopic studies had revealed the dynamics of the flow of gases in the spots. Two days later, Evershed obtained more spectra which confirmed the discovery.

***Figure 2. Evershed at work with the spectroheliograph at Kodaikanal.***

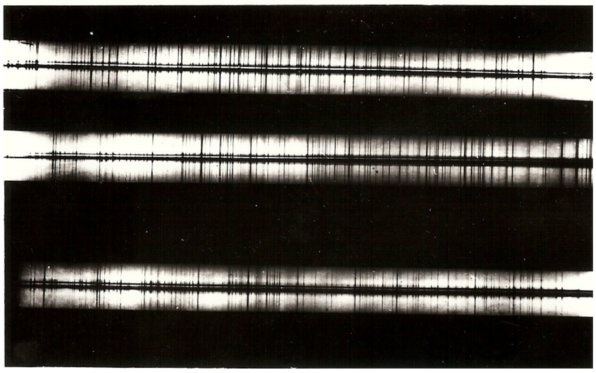


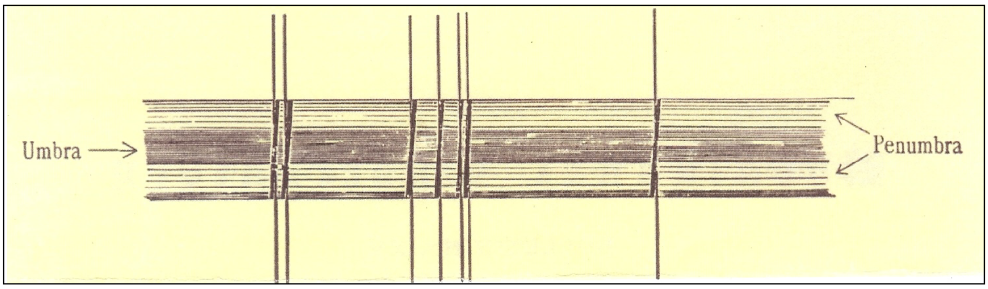
***Figure 3. Solar spectra recorded by Evershed, January 5, 1909 at Kodaikanal.***

Earlier studies had concentrated on spots near the central meridian of the Sun. Evershed was the first to observe spots at various positions, up to 50 degrees, on either side of the central meridian. He found that the line displacements were more pronounced in the penumbral regions of the spots which are closer to the limb of the Sun. This established that the flow of the gases was radially outward parallel to the surface of the Sun. The Evershed effect was discovered.

In 1911, Evershed put into operation a second spectroheliograph as an auxiliary to the Cambridge instrument utilising its perfect movement and using a grating and special arrangements for getting photographs of the solar disk in H-alpha. As red-sensitive plates became available, he started obtaining daily spectroheliograms in H-alpha along with the same in the Ca II K line.

In 1913, the Eversheds visited Kashmir on three months' leave and found the observing conditions in the Kashmir Valley excellent for solar work. He wrote, 'The Valley of Kashmir is a level plain containing a river and much wet cultivation of rice. It is 5,000 ft above sea level and is completely surrounded by high mountains. Under these conditions the solar definition is extremely good at all times of the day, and unlike most high level stations it is best near noon and in hot summer weather.' He established a temporary observatory near Srinagar in 1915–16 obtaining very high-quality photographs of prominences and sun spots. This experience of Evershed was later extended to various locations including one on an ocean liner in tropical

***Figure 4. Line sketch of the spectra obtained by Evershed shows the shift of the absorption line in the penumbra around the sun spot.***



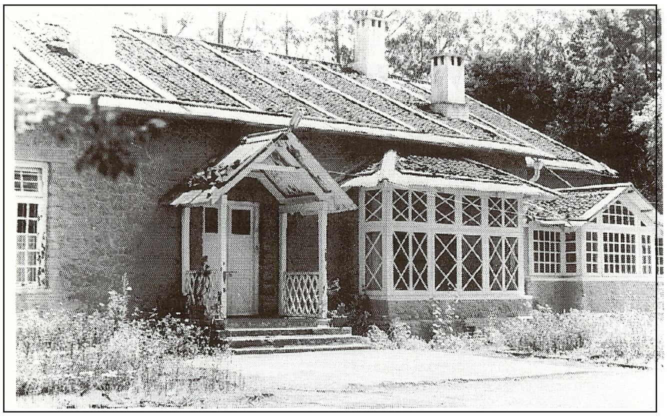


***Figure 5. Evershed Hall in Kodaikanal; the Eversheds stayed here from December 1907.***

waters. The view that the best solar definition is found in low level plains near the sea or on small islands surrounded by extensive sheets of water grew out of these experiences.

In 1915, Evershed was elected a Fellow of the Royal Society and he was awarded the Gold Medal of the Royal Astronomical Society in 1918. At the latter award the President of RAS, Major P.A. MacMahon gave a full account of Evershed's work up to that time giving maximum prominence to the discovery of the radial motion in sun spots. The other contributions that he highlighted were (i) prominence observations, (ii) spectra of sun spots in general, (iii) investigations into the reversing layer, (iv) the minute displacements of lines at all parts of the solar disk, (v) eclipse and cometary observations, and finally, (vi) the invention and perfection of instruments of observation and measurement. Major MacMahon compared Evershed with Sir William Huggins saying 'There is much in our medallist's career which is a reminder of the scientific life of William Huggins. They come from the same English neighbourhood, and began as amateurs of the best kind. They both possess the same kind of scientific aptitude.'

John Evershed retired in 1923 and left Kodaikanal for England. The Eversheds returned to Surrey, where John Evershed established his own obsevatory in Ewhurst near Guildford and continued with his solar observations for well over another thirty years. He and Mary continued to take part in solar eclipse expeditions and also attended meetings of the IAU every three years. Mary died in 1949 at the age of 83 and John Evershed in 1956 at the age of 92.

## Suggested Reading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***Address for Correspondence:*** D C V Mallik, Indian Institute of Astrophysics, Sarjapur Road, Bangalore 560 034, India. Email:dcvmlk@iiap.res.in