IN THE PURSUIT OF STARS AND SOME SUNSHINE

By
Prof R C Kapoor*
rck@iiap.res.in

IIA COMMEMORATES THE DISCOVERY OF EVERSHED EFFECT

As a premier institute for astronomical research in the post independence India, the Bangalore based Indian Institute of Astrophysics has been a centre of extensive activity in theoretical and observational studies of celestial objects and development of specific instrumentation over its 200 years plus history. The observatories of the Institute are located at Gauribidanur, Hanle, Kavalur and Kodaikanal and there are several astronomical discoveries to its credit.

The year 2009 marks one hundred years of the discovery of Evershed Effect in 1909 at the Kodaikanal Observatory which is one of the major findings made in solar physics from Indian soil. This was in fact the first astrophysical observation of interaction between plasma and magnetic field and has played an important role in our understanding of the physical properties of sunspots and the evolution of solar activity (See Box 1). The Indian Institute of Astrophysics commemorated the discovery with an international conference entitled '**Magnetic coupling between the interior and the atmosphere of the Sun**', during Dec 2-5, 2008, a release of a commemorative stamp and first day cover on Dec 2, 2008 and a Vainu Bappu Memorial (Public) Lecture on Dec 3, 2008. The meeting mainly focused on the critical issues pertaining to the solar magnetism and the various magnetohydrodynamic processes in the solar atmosphere and the current status of magnetic field measurements and their implications for recent theoretical studies of highly magnetized turbulent plasma in the light of results from space missions like STEREO and HINODE.

THE MADRAS AND KODAIKANAL OBSERVATORIES

It may be pertinent to mention here that the earliest use of a telescope to observe an astronomical event from the Indian soil dates back to the 17th century itself, a little over 40 years later than Galileo's first astronomical use of it. Although there were instances of occasional use of telescopes over the eighteenth century for observing astronomical events, as a regular activity, the first astronomical observatory to come up on the Indian soil was a private one. William Petrie, an officer with the East India Company, established an observatory at Egmore in Madras in 1786. The observatory was taken over by the East India Company in 1790. It moved over to its new premises at Nungambakkam two years later whence forth it came to be known as the Madras Observatory. It is this observatory that evolved to the present day Indian Institute of Astrophysics.

The Madras Observatory initially came to serve as the reference meridian for the work on the Great Trigonometrical Survey of India. Subsequent work at the Observatory was mainly positional astronomy - recording positions of bright stars on the celestial sphere. Introduction of new instruments in the early nineteenth century enabled work of greater astronomical relevance and precision. The highlights include the preparation in 1843 by Thomas Taylor of the famous Madras Catalogue, Norman Pogson's discovery of five asteroids and six variable stars and of the variability of light of the star R Reticuli in 1867 by his assistant, C Ragoonatha Charry. During the nineteenth century, a few observatories came up in different parts of the country.

The science of astrophysics came into being with the introduction of spectroscopy and photography to astronomy in the western world, and in India it was pursued in due course. In this regard the most notable development was the identification of a new spectral line in the solar spectrum by Norman Pogson during the total solar eclipse of 1868 that could not be attributed to any known element and thus named as 'helium', by Norman Lockyer. The new element was isolated in laboratory years later. After the great famine of the 1870s, the emphasis changed to solar activity. By 1899 Michie Smith shifted the astronomical activity to Kodaikanal. Equipped with new instruments, and with clear skies and a favourable ambience at an altitude of 2300m the Kodaikanal Observatory began work, centered round the Sun.

The building at the Kodaikanal Observatory where on Jan 5, 1909. Evershed made the discovery of the phenomenon of radial motion in sunspots that is now termed the Evershed Effect.

In 1909, John Evershed made the surprising discovery that the flow of gases in a sunspot was radial - one of the major findings made in solar physics now named as the Evershed Effect. This was in fact the first astrophysical illustration of interaction between plasma and magnetic field and has played an important role in our understanding of the physical properties of sunspots and the evolution of solar activity. During his tenure (1907-23) Evershed added several instruments to the Observatory. The wealth of the photographic material collected at the Observatory has a great archival value since it covers eight sunspot cycles each of 11 years period. Only at the observatories in Paris and on Mount Wilson comparable records exist. The extensive data spanning through a long period now provides a very good opportunity to study the variation in the solar rotation rate using sunspots and calcium K-line plages and variation of supergranulation size with solar cycle phase. In 1934 the Observatory received as a gift a spectroheliscope from Mount Wilson Observatory that has been used for visual observations of the sun. A new solar tower telescope was acquired in 1958 that has served as a premier equipment for spectroscopic studies of the sun.

John Evershed working with his spectrograph

A notable phase in the history of the Kodaikanal Observatory began with the arrival of M K Vainu Bappu in 1960 as director. Until that time the Observatory specialized in solar astronomy. There was no modern equipment to be used for intensive work in night-time astronomy. One needed large telescopes and sophisticated auxiliary instrumentation to be in tune with the times. So, Bappu set about to find a suitable location that has access to southern skies as well as proximity to centres of technology. His efforts bore fruits and an observatory was set up, in the middle of sandalwood forests and Javadi Hills at Kavalur. The beginning was humble, with an indigenous 34 cm reflecting telescope that was put to use in 1968. Four years later a 102 cm Carl Zeiss telescope was acquired and installed. Ever since, the Institute has marched on building state of the art astronomical facilities for studies of the universe in nearly all wavelength bands. It has set up observatories at several locations including those in the difficult Himalayan regions and is an active participant in space astronomy today.

BOX 1

THE EVERSHED EFFECT

Evershed obtained the spectra of a sunspot on January 5 and January 7, 1909, in order to determine the gas pressure in the sunspots. He found that the spectral lines were minutely displaced in the spectrum of penumbral region. Although astronomers had spectroscopically observed sunspots since long such a shift of lines was detected for the first time by Evershed. In particular he found:

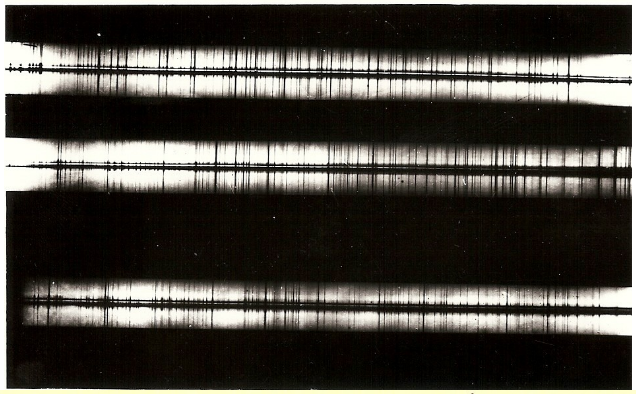
(i) The same amount of line shifts for sunspots equidistant from the center of the disc; the lines showed violet (negative) shifts in the case of penumbrae towards the center of the disc, and, red (positive) shifts in the case of penumbrae towards the limb.

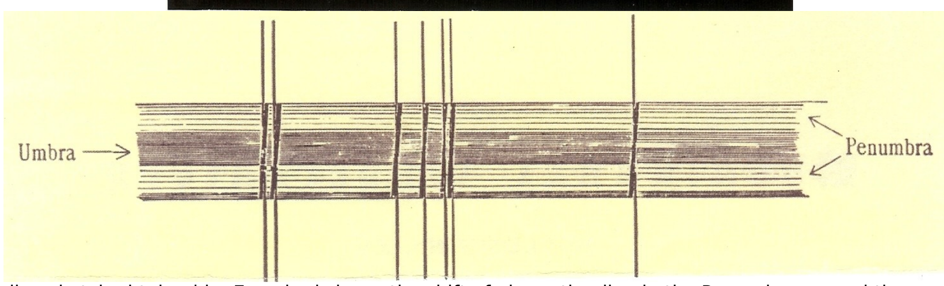
(ii) The shifts disappeared for sunspots within ten degrees of the disc centre;

(iii) The shift of spectral lines to be the maximum for a radial slit position.

From these observations he concluded that the spectral shifts are due to the Doppler effect, indicating radial outflow of solar plasma in sunspots parallel to the solar surface with a velocity of about 2 km/sec. Much work has been done since then on this phenomenon in weak photospheric as well as strong chromospheric spectral lines such as Calcium H and K. In particular, the reverse phenomenon of inflow is noticed in chromospheric lines. A simplified picture of the Evershed effect is as follows:

In a sunspot, the motion at the phtospheric level consists of a predominantly radial outflow. It is largely confined to the penumbra with a velocity of a few kilometers per second. The velocity increases with the size of the spot and also with depth. In contrast, the motion at the chromospheric level consists of a radial inflow of the plasma with a velocity of about the same magnitude.





The line sketch obtained by Evershed shows the shift of absorption line in the Penumbra around the sunspot.

BOX 2

THE IIA ARCHIVES
By Dr Christina Birdie*

The libraries of the Institute are a bibliophile's delight. The main library is at Bangalore. Since the Library is more than 200 years old it boasts of a valuable archival collection. Most of the archival literature is kept in its Archives, specially developed at the Bangalore campus.

The IIA Archives

The Library is in the possession of a rare catalogue for the years 1794-1812 written by calligraphers during the Madras Observatory years. It lists 102 books and journal volumes and 52 manuscripts. Notable among the great historical collections is `Astronomia Nova' (1609) by Johannes Kepler that is the oldest book in the library. It also has 20 books, published in the 18th century including three volumes of Flamsteed`s `Historiae Coelestis` (1725). The oldest journal volume is `Philosophical Transaction' of 1794 and the oldest almanac available is that for the year 1767. The place of pride however goes to the hand-written "Annual Report" of the Madras Observatory for the year 1792. The archives have put up on display the original photographic plate carrying the solar spectrum taken by John Evershed that bore the spectral line shifts in the spectra of the sunspot penumbrae. The original hand drawn sketches of solar prominences and the picture of the Moon by Evershed are also displayed in the archives. A reference library of the archival material has been created in digital form, accessible from the IIA Open Access Repository (http://prints.iiap.res.in).

*The authors are with the Indian Institute of Astrophysics, Koramangala,
Bangalore - 560 034. (Jan 2009)