Figure 28.1: *Astrolabes from personal collections; the shape is unusual. It has Arabic inscriptions. The heliostat modified and used by Sir C. V. Raman*

28. Advent of Astronomical Instruments and their Impact – the Indian Context

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Abstract

After the pioneering venture of Portuguese on to the Indian soil, several European navigators landed in India. Keeping the political and cultural impacts aside, the valuable contribution towards development of astronomical instruments is discussed here. By 1900 there were several telescopic observations reported from India and several instruments developed for the solar and stellar observations. That made Kodaikanal as one of the best solar observatories of the twentieth century. Kodaikanal observatory not only had solar imaging facilities but stellar spectrographs. Comet Halley's apparition in 1910 has been successfully documented. Coronographs, spectrographs, polarimetric techniques and photometers were also available in India. The Great Trigonometric Survey of India was another successful project. The impact of these on the overall development of modern science in India is discussed here with special emphasis on instrumentation.

28.1 Introduction

It is fairly well known that astronomy flourished in India since many centuries prior to recorded history of the continent, typical date quoted is 1300 BC. Historians also note that after about 300 AD the development was partly influenced by the impact of planetary sciences from the west. This fact is well demonstrated by the texts of the 6^{th} century AD and later. Further modifications incorporated newer ideas from Europeans and Arabians retaining the original concepts.

Here the discussion is limited to the developments around 19^{th} and 20^{th} century since much of the instrumentation was developed during this period.

The first major step in the advancement of observations was the introduction of telescopes both in Europe and elsewhere. Although Galileo pioneered this venture in the beginning of the 17^{th} century, the commissioning of them for regular observations became a reality much later for reasons very well known. The contemporary Indian scenario may be briefly summarized as

1. Mathematical astronomy was very well advanced with many important texts being prepared all over India, although it was restricted to a small group of people. The model proposed by Nilakantha Somayaji was a unification of the heliocentric and geocentric models. It should be noted that although he was a contemporary of Copernicus, the two models were arrived at independently.
2. Observations were carried out with very simple instruments prior to 17^{th} century. The angular diameters of sun and moon were very precisely known and hence the exact timings of the eclipse could be calculated.
3. The precession of equinoxes was known although the method used for calculating ΔT is not explicitly discussed in any text.
4. Observatories were functional with the name Vedhshala; the only surviving one is at Ujjain. This was known to Greeks as Uzene.
5. Jaisingh established gigantic instruments in the 18^{th} century for improving the accuracy of measurements.

The measuring instruments like sextants, astrolabes were adopted by local artisans and manufactured locally. Fig. 28.1, S. 250, shows astrolabes of different shapes (uncommon in Europe) with Arabic inscriptions.

28.2 Advent of Telescopes

Telescopes were introduced in India by European travelers even before the East India Company was formed. The first record of a gift of telescope is of the early 17^{th} century to the Mughal Emperor Jahangir by Thomas Roe. Colonisation of Goa by the Portuguese was in 1510, followed by the academic activities of Jesuits. Father Anthony Monserate (1536–1600) accompanied Akbar to determine the latitude of longitudes of places Jesuits gifted them to Jaisingh and much later other travelers also. Sawai Jaisingh used the telescope for planetary observations; historians have criticized his attitude of having resorted to masonry instruments in spite of the advent of telescopes elsewhere in the globe. However, this has been justified considering his contact with Jesuits, who were Catholics opposed to the doctrines of

Galileo. His telescopic observations have been documented. They are

1. The ellipticity of the orbits of moon and sun
2. Phases of Mercury and Venus
3. Sunspots and rotation
4. Four satellites of Jupiter
5. Ellipsoidal shape of Saturn
6. Motion of stars, differences in their velocities.

Father Jean-Venant Bouchet (1655–1732) used a telescope in Pondicherry in 1689 for longitude and latitude measurements. He was joined by Father Jean Richaud; together they recorded observations from a 12 ft telescope. There is also a record of a 17 ft telescope which was used by Claude Stanislaus Boudier for simultaneous observations of planetary phenomenon along with Father Guabil in Beijing.

Transit of Venus in 1874 was a very important event and attracted the first ever international collaboration. Le Gentil proceeded to India exclusively for this observation but was unfortunate enough to miss both the transits. The details of his observations and the instruments that he used (and probably left behind) are not known.

Apart from the telescopes other instruments started landing in India after the EIC took over. That effectively saw the end of the Jesuit era, which produced very fruitful results like the discovery of binary nature of Alpha Centauri and so on. Again, here the details of instruments are not documented anywhere.

The highlights of research work carried out during the later part of the 19$^{\text{th}}$ century may be identified as the discovery of helium in the solar eclipse of 1868 and the fabrication of a coronograph. However, the instruments themselves were used for further modifications and are not traceable now.

By the end of 20$^{\text{th}}$ century there were several well established Observatories – the Madras Observatory was the best among them. The origin of this observatory is well documented at Kodaikanal. Initially it had very simple instruments – quadrants, achromatic telescopes and clocks with compound pendulum, time keepers and a transit instrument. Several lunar occultations were observed from here apart from eclipses and variable stars. Comet Halley in 1836 and 1910, Comet Wilmot in 1845 and several others were observed.

The instruments that were added later are the 6.5″ equatorial telescope in 1845 and a meridian circle in 1856. The orbit of Alpha Centauri was calculated here by Taylor. The "new planet" Neptune and satellites of Saturn and Jupiter were best observed. The Observatory is also credited with the first photographs of the total solar eclipse in 1868 and 1871. The questions raised by the procedures led to the development of another observatory at Dehradun for daily photographs of the sun.

Apart from the Madras Observatory, there were several other short-lived observatories that sprang up during this period (19$^{\text{th}}$ – 20$^{\text{th}}$ century). There are the following important observatories (and many more):

Calcutta Observatory (1825)

Royal Observatory, Lucknow (1832)

Travancore Observatory (1837)

Poona Observatory (1842).

All of these eventually became the network of the India Meteorological department, carrying out routine weather observations. However, some have been identified in personal collections and are traceable in museums. Most of the instruments were brought by the surveyors. Some of those instruments are zenith sector, transit telescopes, drum chronographs, astronomical clocks.

Later additions were "electrically" driven. Thus in 1872 the first electro-telegraphic determination of longitude was possible at Madras and Bangalore. The expensive equipments which were procured for the survey were left behind for various reasons and eventually made available for astronomy.

There were many attempts to revive the interest in positional astronomy since it played only a secondary role for all practical purposes. This is best indicated by a comment by Sir George Everest as a remark on the loan application for setting up an observatory in Poona: *"the discovery which astronomers ... are likely to make in science would hardly repay the inconvenience occasioned by retarding the operation of the Great Trigonometric Survey of India...."*
This is one of the main reasons for the closure of the observatories after the survey was over.

28.3 Dawn of Astrophysics

Initial observations were oriented towards positional astronomy. Norman Pogson as the first non surveyor director of the Madras Observatory initiated observations of what was termed "physical astronomy". Thus the observatory at Kodaikanal was equipped with photoheliograph, spectrograph and similar instruments.

Around the same time a first Indian astrophysicist was in the making. Kavasji Dadabhai Naegamvala was awarded Rs 5000 (today equivalent of US$ 500) from the Maharaja Takthasinghji of Bhavanagar in Gujarat to establish an observatory at Poona. He procured a 16.5″ Newtonian reflector with a 4″ finder and a spectrograph. His spectroscopic observations of novae, variable stars and nebulae were published in MNRAS. After his retirements the instruments were transferred to the Kodaikanal Observatory and are still functional.

The period around 1900 may be considered to be very important in the development of astrophysics in India. The Kodaikanal Observatory (Fig. 29.1, S. 254) was very well equipped with several instruments like a 3-prism spectrograph and a new telescope of 12″ with 20′ focal length.

John Evershed took charge of the Observatory in 1907 and added several instruments; one of them was a pris-

matic camera. His study of the radial motion of sunspots evolved in to the famous "Evershed effect".

Around the same time (1908) another Observatory at Hyderabad also was blossoming. This was the effort of a rich noble man Nawab Zafar Jung. He procured a 15″ reflector and an astrograph. After his death this was taken over by the Government and even now it is functional.

It is very interesting to note how these small beginnings have helped India achieve success with many observatories today including the world's tallest at Hanle on the Himalayas.

Keeping in mind the theme of this meeting we may summarise the important events as

1. Exposure to new instruments and techniques for the natives who were well versed with the necessary mathematical background. This produced an expert observer like Chintamani Ragoonathacary, the first Indian to become a member of the *Royal Astronomical Society*.
2. Some observatories which started at the initiatives of individuals were closed after his death or retirement. The instruments reached Government funded institutes and were forgotten. However, some have survived till date. A small 6″ was donated to a school teacher in Bengal as a loan for observing the opposition of Mars; the teacher was not in a position to bear the expenses for its shipment back to the US. Neither was the agency interested in getting it back. The telescope reached *Indian Institute of Astrophysics* and is being used even today for planetary observations. The 20″ telescope and the spectrograph used by Kavasji Dadabhai Naegamvala (1857–1938) also are being used even today.
3. Instrumentation talent nurtured as an inevitable solution for servicing the equipments resulted in excellent technicians. The mention should be made of Mir Mohsin whose skills were greatly appreciated; he built a 18″ telescope on his own. He was called from Madras to Calcutta to work for the Great Trigonometric Survey; the recommendation for his higher salary reads – *"though he could not read English, he would have taken a leading place among European instrument makers"*.
4. The impacts of these instruments naturally lead to well equipped university laboratories, which were beginning to attract natives. Many institutes heavily depended on imported equipments and local technicians were trained to service the same. This generated a new breed of instrument makers for special skills of glass blowing, lathe operation and so on. The best example is that of a heliostat which was used by Sir Chandrasekhara Venkata Raman (1888–1970). This devise would let a mirror track the sun and throw the light onto a spectrograph. It was a simple modification of a small alarm (spring loaded) clock (see Fig. 28.1, p. 250). The sunlight itself was the source of light for the famous molecular spectroscopy experiments whose results are known to us today as "Raman effect", which fetched him a Nobel Prize.

28.4 Conclusion

The impact of the European instruments on the development of modern science in India is invaluable. It nurtured local talent and elevated them to reach international standards in spite of the political and sociological hurdles. Thus India at the dawn of independence in 1947 had a very respectable opening balance.

28.5 Acknowledgements

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