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INDIAN INITIATIVES TO ESTABLISH 'WESTERN' ASTRONOMICAL OBSERVATORIES PRIOR TO INDEPENDENCE. 2: COLLEGES AND UNIVERSITIES

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Abstract: This paper outlines the efforts to establish Western-style astronomical observatories in India made by colleges and universities over the last century prior to Indian independence in 1947. The focus is therefore on the nineteenth-century emergence of the Presidency College Observatory in Calcutta, St. Xavier's College Observatory in Calcutta, Takhtasinghji Observatory in Poona, and Langat Singh College Observatory in Muzaffarpur.

Three of these observatories were established either to aid educated Indians in gaining a realistic knowledge of Western astronomy, or so that India itself could contribute to that body of research knowledge. The fourth observatory, at the Presidency College in Calcutta, was a local government initiative founded primarily to provide a local time service and meteorological data.

Unlike the observatories discussed in the first paper in this series, none of the observatories reviewed in this paper was set up primarily to further Britain's colonial ambitions. All were local Indian initiatives, but the critical involvement of Western astronomers or academics at three of the four observatories reveals that a colonial link was still there, albeit as an underlying element.

Keywords: Indian astronomy, Presidency College Observatory (Calcutta), St. Xavier's College Observatory, Takhtasinghji Observatory, Langat Singh College Observatory

1 INTRODUCTION

This is the third of four papers that discuss the establishment of modern astronomical observatories in India over the two centuries preceding Indian Independence in 1947. The first paper (Kapoor and Orchiston, 2023) discussed the observatories at Madras, Colaba, Kodaikanal, Calcutta and Dehra Dun that were set up as British colonial institutions, along with the Great Trigonometrical Survey of India, and overseas and local expeditions mounted in response to a succession of total solar eclipses and two transits of Venus. The second paper (Orchiston and Kapoor, 2023) focussed on those astronomical observatories that were founded by Indian aristocrats in Lucknow, Trevandrum and Hyderabad. This paper discusses observatories established by four Indian educational institutions located in Calcutta, Poona and Muzaffarpur, and the final paper in the series will review Indian observatories maintained by Indian and expatriate amateur astronomers. Indian localities mentioned in this paper are shown in Figure 1, and in order to retain the historical flavour we have retained the old names and spellings that were used in the original historical accounts.

For reviews of the development of modern astronomy in India during the nineteenth century and first half of the twentieth century see Ansari (1985; 2000), Kochhar and Orchiston (2017), and Sen (2014).

2 THE EMERGENCE OF WESTERN EDUCATION IN INDIA

The evolution of an English style of education for the Indian 'elite' is a broad fascinating topic that has already been written about by others (e.g. see Nurullah and Naik, 2000, and references therein), and is beyond the scope of this paper. Instead, we focus here on the emergence of colleges and universities that taught astronomy and established astronomical observatories during the second half of the nineteenth century. This movement was part of the 'Indian Renaissance', when

> … British dominance had also begun to greatly overwhelm India's political, cultural and economic life … [and] place Medieval India on the path to modernity. (Orchiston and Kapoor, 2023: 925).

The East India Company (EIC) played a critical role in this. Although it was founded in 1600

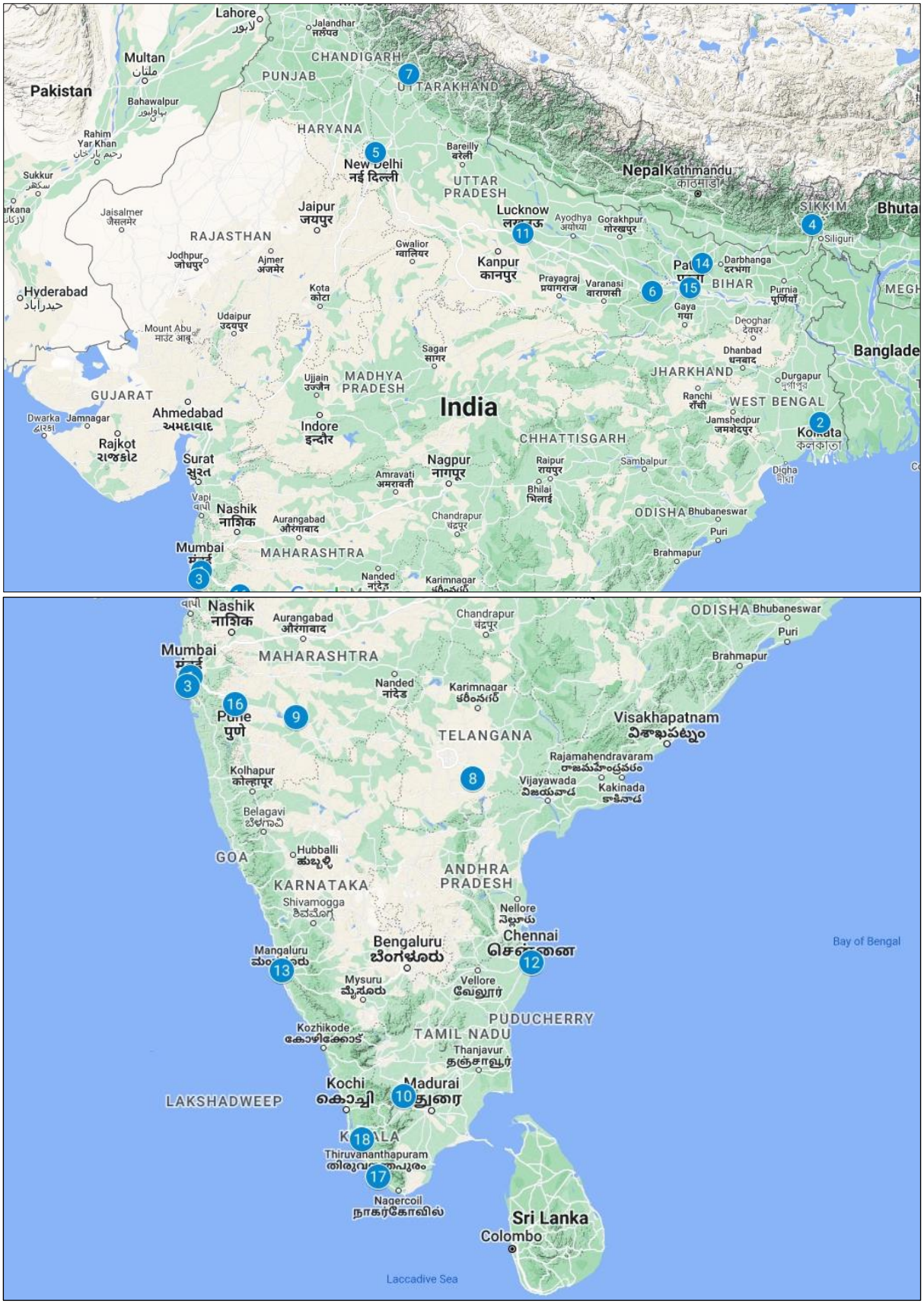


Figure 1: Maps showing Indian locations mentioned in the text: 1 = Bombay (partly hidden under 3), 2 = Calcutta, 3 = Colaba, 4 = Darjeeling, 5 = Delhi, 6 = Dumraon, 7 = Dehra Dun, 8 = Hyderabad, 9 = Jeur, 10 = Kodaikanal, 11 = Lucknow, 12 = Madras, 13 = Mangalore, 14 = Muzzaffarpur, 15 = Patna, 16 = Poona, 17 = Trevandrum, 18 = Bankura (made from Google My Maps; map modifications: R.C. Kapoor).

and had a long and intricate involvement in Indian politics and commerce (Keay, 1991; Lawson, 1993), it only became legally responsible for education of the Indian population with the implementation of Section 43 of the Charter Act of 1813 (Basu, 1867).

During the late eighteenth and early nineteenth centuries the EIC had brought a major part of India under its control, which it divided into four administrative regions. These were the Presidencies of Bengal, Bombay, Madras and the North-West, which explains the establishment of the Presidency College in Calcutta in 1855. St. Xavier's College in Calcutta, the Government College of Science in Poona and Langat Singh College would all come later.

It is telling that two of the four institutions discussed in this paper were located in Calcutta, the early centre of the Indian Renaissance. This was where science education took root in India (Pallt, 2000). It also witnessed the birth of English education in schools, with the founding of the Hindu College in 1817 and the Calcutta School Book Society in 1818 (Majumdar et al., 2007). The Society published many books on scientific subjects, including astronomy, in English and in different Indian languages.

Various scientific and technical magazines also were launched in Bengal during the first half of the nineteenth century (Bhattacharya et al., 1989; Raina, 2000), and reports on astronomical events (e.g. eclipses, meteor showers) and objects (comets) appeared in local newspapers and magazines.

While English education started in Bengal, it soon spread into neighbouring regions, and then to other Presidencies and Provinces.

It is within this historical context that we now discuss Indian astronomical observatories that were established by colleges and universities during the nineteenth century.

3 OBSERVATORIES FOUNDED BY EDUCATIONAL INSTITUTIONS

3.1 The Presidency College Observatory, Calcutta

Hindu College in Calcutta was established in 1817 with a view to providing modern, Western education in the English language for aspiring Indians. The foundation committee was led by the famous educationalist and social reformer Raja Ram Mohun Roy (1772–1833; Sharma, 2002), who has been described as the 'Father of the Indian Renaissance' (*ibid.*).

The College made a humble start, but soon it began to chart a path to progress and was renamed Presidency College in 1855 (Figure 2). Eventually, the College evolved into Presidency University.

In a letter dated 30 November 1905, Phanindra Lal Gangooly (1906: 66) from the College shared with the readers of *The Observatory* journal the following information about the astronomical facilities at the College:

> An astronomical observatory, recently established by the Government of Bengal, is attached to the Presidency College, Calcutta, the premier Government College in India. Our astronomical equipment at present comprises two transit-instruments by T. Cooke & Sons, a few good chronometers, two astronomical clocks, a chronograph, and two equatorial telescopes, one of 7 inches aperture by Sir H. Grubb, and the other of 4½ inches aperture by T. Cooke & Sons, the latter being provided with a photographic apparatus.
>
> Prof. A. Little, of the Presidency College, is in charge of the Observatory, and has a few Bengali assistants, who have been employed in making meteorological observations, keeping the Time Service going, systematically observing double stars in some portions of the southern hemisphere, and in observing Moon-culminations with a view to determine the longitude.
>
> The latitude has been found by Talcott's method to be 22° 34′ 31″ 2 N.

According to the following web site, https://www.presiuniv.ac.in/web/astrohistory.php, the Observatory was set up on the roof of the College's Main Building (long after the photograph shown in Figure 2 was taken). The aforementioned Talcott–Horrebow method of latitude determination uses the zenith difference between two stars, one north and the other south of the zenith at the time of meridian crossing. The measurement can be done with a theodolite or with a zenith telescope provided with a screw-micrometer (Sotome, 1911).

The above-mentioned Professor Gangooly taught mathematics at Calcutta University, and was the Founding Secretary of the Calcutta Mathematical Society when it was formed in 1908. He also edited the translation of the *Sūrya Siddhanta* by Reverend Ebenezer Burgess, reprinted from the 1860 edition and published in 1935.

Appendix IV in the Centenary Volume of the Presidency College (1955: 310) mentions a "Little, Charles (1885–1909) – teacher of Mathematics, meteorologist", who was included in

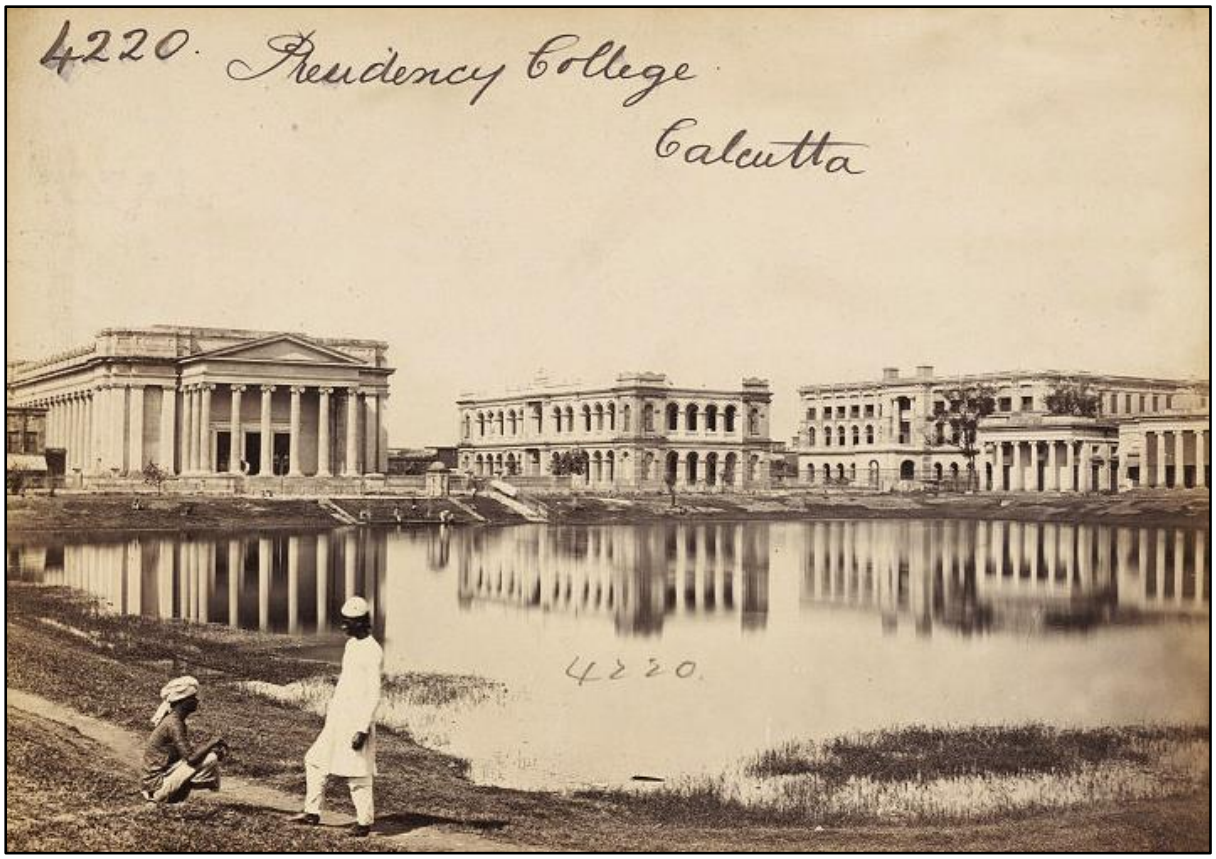


Figure 2: A photograph by Francis Frith of some of the buildings at the Presidency College in Calcutta (https://upload.wikimedia.org/wikipedia/commons/3/3b/Presidency_College%2C_Calcutta_by_Francis_Frith_%281%29.jpg).

the staff list of 1891. Plate 59 in Part IV of the same Centenary Volume also shows him in a group photograph of the winners of the Elliot Shield in 1907, and refers to him as the Principal of the College. The shield was named after Colonel Elliot who was the British Administrator of Calcutta and a great lover of football.

The 'History' entry in the Astrophysics section of the Presidency University web site reports that

> Regular observations of solar system planets and other objects were made and reported in the journals published by the early Astronomical Society of India in Calcutta. The telescope was in operation till the 1960s when the students of the Astronomy course in the Mathematics department used it. (https://www.presiuniv.ac.in/web/astrohistory.php accessed 20.11.2022; their underlining, not ours).

We were unable to view any of these publications, and no observational papers by Gangooly, Ganguly or Little were found during an ADS search. The reported regular observations of Solar System objects were carried out with modest instruments and published locally instead of in international journals. Therefore, it is safe to assume that original cutting-edge astronomical research was not being carried out at the Observatory.

Currently the observatory still exists, on the roof of the main building (see Figure 3), and although part of the mounting of the 7-inch Grubb telescope is *in situ*, the telescope itself has been removed (Figure 4). It appears that the walls of the observatory require some attention, but the dome itself is still sound. At the time of writing (March 2024) the School of Astrophysics plans to install a 12-inch reflector in the observatory.

3.2 St. Xavier's College Observatory

The second observatory we shall discuss in this paper was founded by the Jesuits in Calcutta in 1877.

The Jesuits are an order of the Roman Catholic Church that was founded by the Basque Spaniard Francis (later Saint) Xavier 1506–1552) and six companions in 1540. The Jesuits have a special interest in mathematics and astronomy (see Udias, 2003; 2015), and they played a key role in the development of 'modern astronomy' in China (Shi, 2020; Udias,

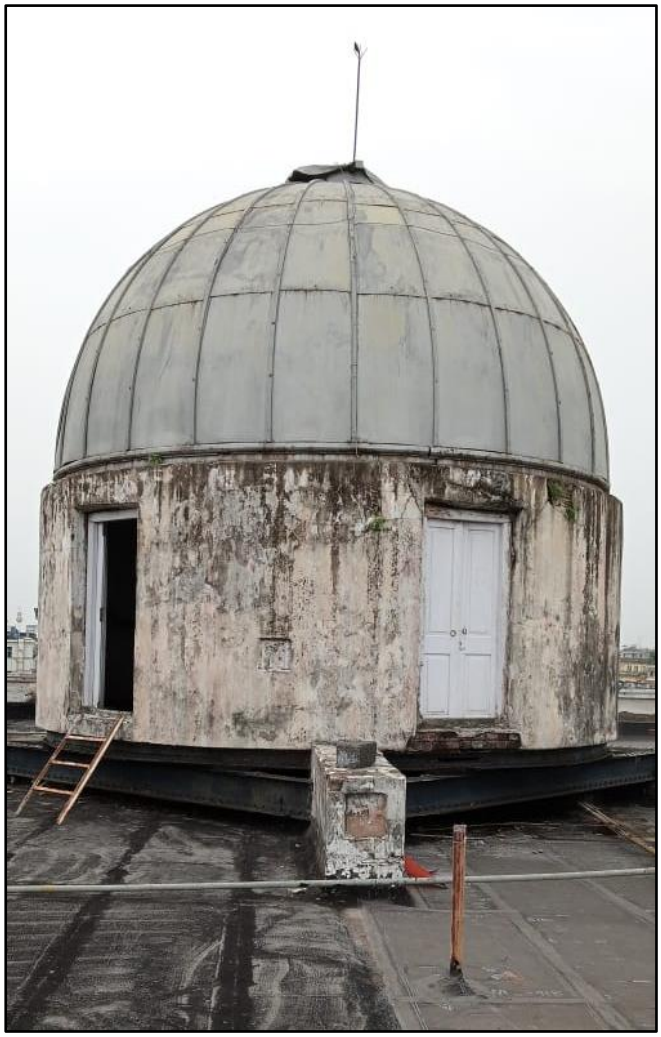


Figure 3 (above): The old observatory at Presidency University (courtesy: Dr Saumyadip Samui).
Figure 4 (right): Part of the mounting for the 7-inch Grubb refractor (courtesy: Dr Saumyadip Samui).

1994) and Siam (Orchiston et al., 2019; 2021). They also were active in India from the 1680s (Kameswara Rao et al., 1984; Kochhar, 1991: 95), a reflection perhaps of Saint Francis Xavier's own interest in India, where he successfully proselytized from the time he first arrived in India in 1542, just two years after his Jesuit order was founded (see Brodrick, 1952). However, this paper focuses on an observatory that was established by the Jesuits at St. Xavier's College in Calcutta more than three centuries later.

St. Xavier's College (Namboodiry, 1995) was founded in January 1860, with

> … a vision of imparting the best European education to catholic settlers in the city along with the locals. The first prospectus clearly stated, "The course of studies is similar to that pursued in the great colleges of Europe" and it included subjects like mathematics, trigonometry, and the natural sciences. (Katti, 2022).

Astronomy was one of the 'natural sciences'.

As is sometimes the case in astronomy, the establishment of an observatory at St. Xavier's College in Calcutta was due largely to the vision and passion of one man, in this case Father Eugene Lafont (1837–1908; Figure 5). Lafont (Biswas, 2001) was born and trained for the ministry in Belgium, before completing degrees in Philosophy in Tournai and Natural Sciences in Namur. In 1865 Lafont was assigned to St. Xavier's College to teach science, and the 28-yr old arrived in Calcutta on 4 December as Professor of Physics. One of his first tasks was to establish a science laboratory.

Lafont soon gained widespread visibility in India when in 1867 he predicted

> a devastating cyclone that was approaching the city, based on his regular meteor-

Figure 5: Fr. Eugene Lafont (Wikimedia Commons).

> ological observations carried out using a barometer in his rooftop lab. He immediately informed the local British government authorities who had missed it. Thanks to him, immediate measures were taken to save lives. Thus, he became a new reliable scientific weather forecaster for the Indo-European Correspondence, the weekly newspaper that was published in Calcutta. (Katti, 2022).

Apart from meteorology, Lafont's interests in science and technology were wide-ranging, and astronomy was merely one of these. But it was a rare astronomical event, the 1874 transit of Venus, that ultimately inspired the construction of an astronomical observatory at St. Xavier's College. By this time, Fr. Lafont was Rector of the College (Chinnici, 1995/1996: 94).

After James Gregory, Edmund Halley and Joseph-Nicolas Delisle explained how transits of Venus could be used to resolve the most pressing problem in international astronomy—the mean distance from the Earth to the Sun—the 1761 and 1769 transits assumed major importance (Sheehan and Westfall, 2004). But the results from the various international expeditions were disappointing (Woolf, 1959). So the focus then shifted to the 8/9 December 1874 transit (Cottam and Orchiston, 2015), and the Italians decided to establish an observing station at Muddapur in Bengal.

Figure 6: Palermo Observatory's Pietro Tacchini (https://en.wikipedia.org/wiki/Pietro_Tacchini#/media/File:Pietro_Tacchini,_ante_1905_-_Accademia_delle_Scienze_di_Torino_0110_B.jpg)

Unlike most 1874 international expeditions, the Italian team would rely on spectroscopic observations of the transit (Pigatto and Zanini, 2001) led by Pietro Tacchini (1838–1905; Figure 6), the Astronomer at Palermo Observatory. During the transit Tacchini (1875) observed the spectrum of Venus and "… also validated the use of spectroscopic observations to determine the exact instant of limb contact." (Gariboldi, 2014: 2121). Meanwhile, Fr. Lafont, who had joined the Italian transit expedition, broadened his astronomical horizons by learning first-hand how to carry out successfully spectroscopic observations of the Sun.

Tacchini was impressed with seeing conditions for solar observing in India, and he also noted that in those months when there was maximum rainfall in Palermo there was minimum rainfall in Calcutta, and *vice versa*. Moreover,

> … the best months to observe in Calcutta were also the cooler ones, with great advantage to the observers. And since the difference of longitude between Calcutta and Palermo was about five hours, the observations would never be simultaneous … (Chinnici, 1995/1996: 94).

He therefore suggested to Fr. Lafont that they establish an observatory at St. Xavier's College that could work in tandem with Palermo Observatory on a co-ordinated spectroscopic study of the Sun.

Fr. Lafont was persuaded, and while he launched a public fund-raising appeal Tacchini was busy designing the new observatory. By March 1875 there were enough donations for Tacchini to order a 7-inch (17.8-cm) equatorial refractor from the celebrated German telescope-maker, Merz. However, delivery was anticipated to be in 1877.

At the same time, through the *Memorie della Società delgi Spettroscopisti Italiani*, Tacchini informed his international colleagues that

> The eminent father Lafont … has accepted the proposal to build an Observatory in Calcutta in his College with the aim of

Figure 7: A photograph of part of St. Xaviers College during the nineteenth century, including the Observatory (courtesy: INAF-Osservatorio Astronomico di Palermo, Library).

> carrying out there regular solar observations which (…) could fill the inevitable gaps of our [Italian] Observatories because of the too often overcast sky in (winter) months. (Chinnici, 1995/1996: 95).

Tacchini (Chinnici, 1995/1996: 95–96) also mentioned that construction of the observatory, with its 10-ft diameter drum dome for the Merz refractor, was nearly completed. Figure 7 shows the completed observatory.

While waiting for the arrival of the Merz telescope Fr. Lafont attached a spectroscope to a small refractor and used this to practise observing solar spectra. However, towards the end of 1876 his patience may have been running thin because he then talked about installing in the dome an equatorially mounted refractor with a 9-in (23-cm) Stenheil objective (Chinnici, 1995/1996: 96).

Finally, on 12 June 1877 Fr. Lafont wrote Tacchini that the observatory was operational, complete with the Merz and Steinheil refractors, three spectroscopes, an excellent astronomical clock and a chronometer (Chinnici, 1995/1996: 98). He added:

> I think that, with these instruments, a clear sky and some practice, next winter I should be able to send you my observations of the solar limb. (*ibid.*).

Instead, further delays occurred as Fr. Lafont considered retaining the Merz telescope and selling the Steinheil refractor to defray expenses, and it was only on 28 May 1878 that he wrote Tacchini:

> … I send you some observations which the excellent weather conditions of the season have allowed to carry out. *Do not publish them, for these are my first trials with the Editon's electric pen, which, I think, will be very useful to me when publishing my observations about [the] solar limb* … (Chinnici, 1995/1996: 99; our italics).

Sadly, these would appear to be the only solar limb observations that Tacchini received from Fr. Lafont, who by November 1878 was seriously ill and went to Europe for a year to convalesce. In the meantime, one of Tacchini's key Italian collaborators, Fr. Angelo Secchi had died in 1878. As a result, Tacchini acquired new responsibilities, and had less time to devote to solar spectroscopy, so when Fr. Lafont did return to India at the end of 1879 there was not the same urgency to continue the solar collaboration. Moreover, he had additional responsibilities associated with the University of Calcutta which left him with less time for the St. Xavier's College Observatory or the solar spectral project.

Table 1: Astronomical reports by Fr. De Penaranda published in the *Indo European Correspondence*, 1882–1896.

Date*		Report
1882	May	Observations of the partial solar eclipse on 17 May
1889	September	Observations of the conjunction of Mars and Saturn on 20 September
1890	February	Favourable position of Neptune for observation
	March	Up-coming conjunction of Mars and the double star β Scorpii on 5 March
	June	Observations by a St. Xavier's College team of the annular solar eclipse on 17 June
	November	The conjunction of the Moon and Neptune on 26 November
1891	May	Observations of the transit of Mercury on 10 May
1892	October	Observations of the occultation of Jupiter by the Moon on 6 October
1893	Throughout the year	"… St. Xavier's Astronomical Observatory published as many as 13 reports on the astronomical occurrences including the sun, moon, transit and conjunction of many planets." (Ghosh, 2019: 217).
1895	February	"… Fr. Penaranda published in the *IEC* an elaborate study of the Inverted image on the retina and explained the mathematical precision of the indications furnished by our eyesight." (Ghosh, 2019: 217).
1896		Information about the up-coming total solar eclipse of 21/22 January 1898

* Note that Biswas (1894) incorrectly dates some of these events.

However, Fr. Lafont was not the only astronomer at St. Xavier's College: on 14 November 1874 he had been joined by the Spaniard Fr. Alphonse De Penaranda S.J. (1834–1896; Ghosh, 2019). Fr. De Penaranda had wider-ranging astronomical interests than Fr. Lafont, and

> … contributed regularly on the 'Astronomical Occurrences' column in the journal of *Indo European Correspondence (IEC)* published on every Wednesday during the 1880s. (Ghosh, 2019: 216).

For example, De Penaranda's observations of Mars in 1889 were reported in minute detail (*ibid.*).

After a hiatus of one year (1881–1882), when he was establishing a new Jesuit college in Mangalore, De Penaranda resumed his reports in the *IEC* with an account of the 17 May 1882 partial solar eclipse. After another time-gap, De Penaranda continued to provide astronomical accounts through to the 1890s (see Table 1), the last appearing two years before his death in 1898 at the age of 64.

Earlier this same year the French Jesuit Fr. C. De Clippeleir, S.J., from St. Xavier's College led a Jesuit expedition to Dumraon (Figure 12), where they successfully observed the 22 January 1898 total solar eclipse mentioned on the last line in Table 1. We can be sure that Fr. Lafont would also have liked to join this expedition, but he was now in his twilight years and observational astronomy was but a distant memory. In 1904 he resigned as Rector of St. Xavier's College, but he continued to teach physics for another two years. Then ill health intervened and he retired to Darjeeling in the Himalayan foothills, where he died on 10 May 1908.

Two years later, the Observatory was redesigned and moved to a new site on the campus (Figure 8), but College staff never succeeded in carrying out cutting-edge research in astronomy or astrophysics there (Chinnici, 1995/1996: 101–102). So, despite the early promise, in the end St. Xavier's College Observatory played no part in the international development of solar physics. This primarily was because Fr. Lafont was an accomplished educator and populariser (Katti, 2022),[1] not an observational astronomer, and none of the other staff appointed by the College to teach physics was trained to pursue international-level research in astronomy or astrophysics. Technology had also moved on, and the equipment at the College Observatory was now dated.

The St. Xavier's College Observatory shown in Figure 8 no longer exists, but in 2014 a C-14 Schmidt-Cassegrain telescope was installed in a new 7.3-m domed observatory on the roof of one of the College buildings, along with an adjacent roll-off roof observatory used for solar observing. This current facility is known as the Father Eugene Lafont Observatory. So,

> … St. Xavier's Collegiate School and College continue to groom and produce top scientific talent. The alumni of the physics department currently play an important role in scientific establishments across the country and abroad. Like they say, candle to candle, the flame lit by Fr. Lafont's magic lantern continues to illuminate many young minds. (Katti, 2022).

Figure 8: The relocated St. Xaviers College Observatory (after Katti, 2022).

3.3 Maharaja Takhtasingji Observatory, Poona

An observatory at Poona (present-day Pune) was established in 1888 by His Highness Maharaj Raol Shri Sir Takhtsinhji Jaswantsinhji Sahib of Bhavnagar (1858–1896; r. 1870–1896; Figure 9). This was at the suggestion of Kavāsjī Dādābhāi Naegamvālā (1857–1938; Figure 10; Ansari, 2019), a young Lecturer of Physics at Elphinstone College in Bombay.

Naegamvālā came from a prominent Parsi family of contractors, and was a brilliant undergraduate student at Elphinstone College, graduated with a BA in 1876 and an MA in Physics and Chemistry in 1878, and in the latter year winning the Chancellor's Gold Medal. He joined the College in 1882 as a Lecturer in Experimental Physics and specialized in spectroscopy.

In 1882 the Maharaja was visiting the University of Bombay where he met Naegamvālā who pointed out that:

> ... adequate means for the pursuit of spectroscopic investigation did not exist in any of the Colleges affiliated to the Bombay University and that Elphinstone College would be prepared to organise a spectroscopic laboratory, if provided with a sum sufficient for the purpose. (Cited in Ansari, 2019: 309).

Naegamvālā said he was ready to move ahead with a laboratory if the funding could be arranged. The Maharaja responded by offering Rs. 5000, on the expectation that the Bombay Government would match this, and he subsequently explained his motivation for this beneficence in a letter now housed in the Bombay Archives:

> On one hand I [the Maharaja] have the satisfaction of knowing that I had done something to supply a very desirable means for [the] study of an important branch of science. I shall, on the other hand, have the gratification of thinking that it has permitted me to perpetuate the memory of my present visit … (Cited in Ansari, 2019: 309–310).

The only other spectroscopic laboratory in India at that time was at St. Xavier's College in Calcutta, under Fr. Eugene Lafont, where he was using 9-inch and 7-inch refracting telescopes for solar and stellar spectroscopic observations. Ansari (2019: 311) notes that

> Through Father Lafont's influence, it was natural that Naegamvālā's interest shifted from a spectroscopic laboratory to an astrophysical observatory. After convincing Principal Wordsworth of Elphinstone College, Naegamvālā used recommendations from Father Lafont and Father Deckmann (Professor of Physics at St. Xavier's College) to request funding so that he could visit various observatories and laboratories in Europe …

Naegamvālā then obtained a grant of Rs. 10,000 to purchase instruments in Europe and visit laboratories and observatories there, where he could familiarize himself with the instrumentation that would be needed and the associated observational techniques. After visiting St. Xavier's College Observatory he sailed for Europe, and after going to the College Romano in Rome, Potsdam Astrophysical Observatory and Meudon Observatory in Paris he crossed the English Channel and made for

Figure 9: Colonel H.H. Maharaja Raol Shri Sir Takhtsinhji Jaswantsinhji of Bhavnagar (Royal Archives https://www.facebook.com/RoyalArchives/photos/a.372204173245633/637791590020222/?type=3; accessed 9 December 2022).

Sir Norman Lockyer's Solar Physics Observatory in South Kensington, London. Once there, "… he trained himself in handling new spectroscopic and photographic apparatus …" (Cited in Ansari, 2019: 311).

While in England Naegamvālā also drew up a list of the instruments that he wished to purchase for his new observatory, and he even had it approved by the Astronomer Royal, Sir William Christie. By the end of his European so-

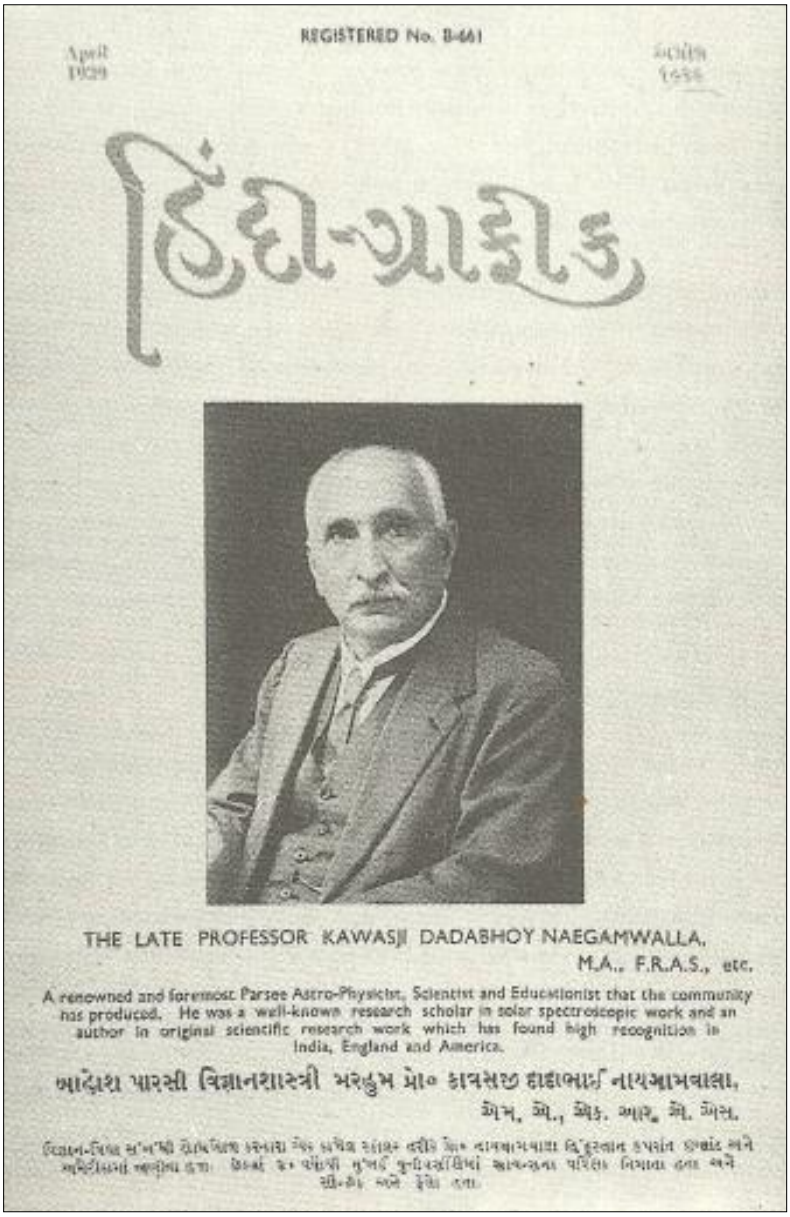


Figure 10: Professor Kavāsjī Dādābhāi Naegamvālā (after Kochhar and Narlikar, 1995: 17).

journ Naegamvālā "… felt confident about establishing an astrophysical observatory in India." (*ibid.*).

Naegamvālā returned to Bombay and for some time he worked in the spectroscopy laboratory at Elphinstone College, but in 1888 he moved to The Government College of Science in Poona.[2] as Lecturer in Astronomy (see Ansari, 2019: 311)—not as a Professor of Astrophysics, as suggested by Narlikar (2003) and repeated by Kochhar and Orchiston (2017).

It was there, in Poona, that Naegamvālā established the Maharaja Takhtasingji Observatory, with a grant from the Maharaja. By the end of 1888 the Observatory was operational (Naegamvala, 1888), and Naegamvālā sent a list of the instruments to the Astronomer Royal. This list included:

(1) A 16½-inch Newtonian Grubb reflector (see Glass, 1997)[3]
(2) A 6-inch equatorially-mounted Cooke refractor
(3) A 12-inch siderostat and solar grating spectroscope
(4) A transit telescope
(5) Spectroscopes
(6) A standard clock
(7) A chronograph.

Naegamvālā was fully aware of the quality of his instruments and wanted to use them to contribute to science. So he wrote to Sir William Christie, who responded:

> It is very desirable that the fine equipment of the observatory … should be fully utilized as such valuable work might be done with it at a station like Poona near the Equator where observations of the Sun, Moon Planets etc. could be made under much more favourable conditions than in our Northern observatories. India seems to be peculiarly marked out for observations of the Sun, especially spectroscopic … (Christie, 1897).

Accordingly, Naegamvālā began research in the fields of astrophysics and solar physics.

One of Naegamvālā's strongest supporters back in England was J. Norman Lockyer, so it is ironic that

> Naegamvālā's first use of the large reflecting telescope was to prove his mentor, Lockyer, wrong. Naegamvālā (1891) showed that the chief nebular line in Orion was sharp under all circumstances and therefore could not be the remnant of a magnesium band as Lockyer had suggested. (Kochhar and Orchiston, 2017: 750).

Needless to say, Lockyer (1898) was far from amused.

Upon researching observations made at the Takhtasingji Observatory and their publication, Ansari (2019: 312) found that between 1888 and 1902 Naegamvālā "… typically published one paper or short communication per year, mainly in *Monthly Notices of the Royal Astronomical Society*." Apart from the afore-mentioned spectroscopic study of the Orion Nebula, a few of these papers were on astrophysical themes (i.e. nebulae, or the spectrum of Nova Persei 1891), one dealt directly with positional astronomy (the 1891 transit of Mercury), and another was on the spectrum of a sunspot group. So Naegamvālā was hardly a prolific publisher, and nor was he a notable contributor to the international growth of astrophysics.

What he did do, however, was make valuable observations of the total solar eclipse of 22 January 1898. The path of totality of this 2 minutes 21 second event crossed central India (see Figure 11), and the nine different observing stations used by the international and Indian eclipse teams are shown in Figure 12. Table 2 lists the different teams.

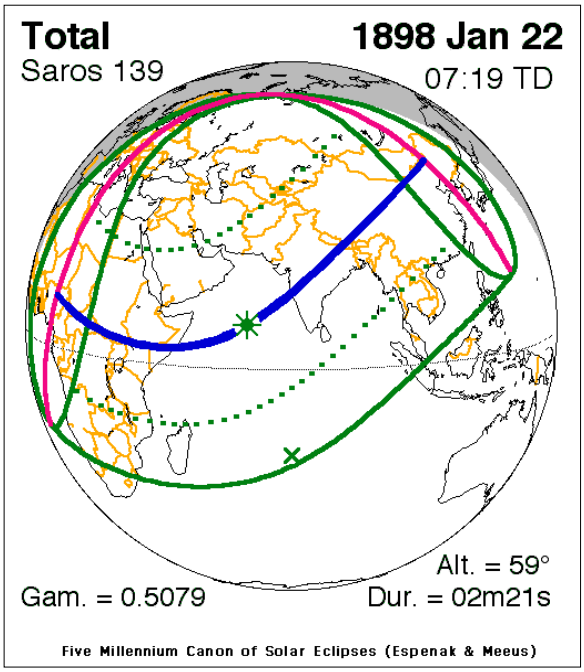
In our understanding of the solar corona, after the 18 August 1868 event the eclipse of 16 April 1893 proved a turning point. This was when observations of relative Doppler shifts in coronal spectral lines by Deslandres proved that the corona rotated with the Sun (Deslandres and Hale, 1896). The total solar eclipse of 22 January 1898 also holds an important place in the history of solar physics. During this eclipse, astronomers detected the spectral line doublet at 5317Å and observed the mysterious 'green line' at 5303Å (which was actually first recorded by Pogson (Nath and Orchiston, 2021) during the 18 August 1868 eclipse, but generally is attributed to Young and Harkness and the total eclipse of 7 August 1869). At the time, the 'green line' was associated with an unknown element, which Grünwald (1887) had termed 'Coronium'. We now know that it is a 'forbidden line' due to highly ionised Fe XIV (Claridge, 1937).

Naegamvālā had earlier participated in the British expedition to Norway for the 9 August 1896 total solar eclipse, but that venture failed due to clouds. For the 22 January 1898 Indian eclipse he chose to observe from Jeur in the Sholapur district of Maharashtra (Figures 12 and 13). Also sited at Jeur were teams from Lick and Tokyo Observatories, while the small Chabot Observatory party was located nearby at Vangi (Table 2). Other eclipse teams listed in this Table were found at the various sites marked by the purple stars in Figure 12. Conspicuous by its absence in Table 2 is a party from Kodaikanal Observatory, arguably India's foremost solar research facility at this time (Kochhar and Orchiston, 2017: 752–756). This is because Evershed and Michie-Smith chose to join one of the British expeditions (see Maunder, 1899) rather than go to the trouble and expense of mounting their own expedition.

Figure 14 indicates that Naegamvālā led a very large eclipse team, but we should note that not everyone was from the College of Science in Poona. For example, Fr. F.X. Haan S.J. from St. Xavier's College in Bombay (not Calcutta) opted to join Naegamvālā's party (which was much closer to 'home'), rather than going to Dumraon where the Jesuit astronomers from St. Xavier's College in Calcutta were stationed. Also present were various officials supplied by the Government in Bombay.

Naegamvālā's primary interest was to obtain spectroscopic observations of prominences, the chromosphere and the corona, "… assigning a secondary place only to the subjects of photographing the corona and of eye-observations." (Naegamvala, 1902: 6). He therefore came to Jeur armed with the following instruments (Naegamvala, 1902: 6–7):

1) An equatorially mounted 6-inch prismatic camera (Figure 14) to record the 'flash' spectrum and the spectrum of the corona.
(2) A 12-inch Boucault siderostat with a 3-inch



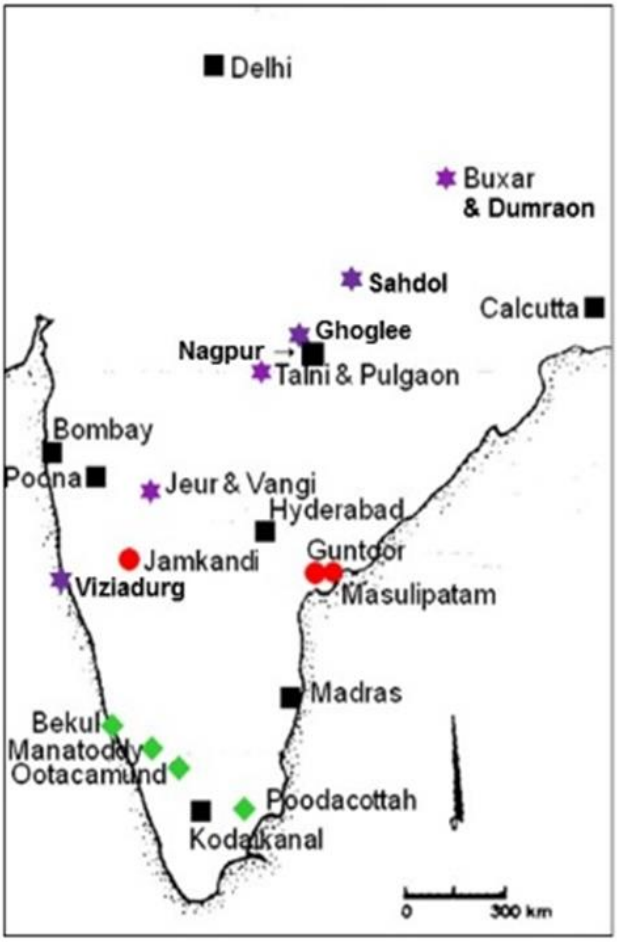


Figure 11 (above): Map showing the path of totality of the 22 January 1898 total solar eclipse across central India (https://en.wikipedia.org/wiki/Solar_eclipse_of_January_22,_1898).
Figure 12 (right): Map of India showing Bombay, Calcutta, Delhi, Kodaikanal, Madras, Poona, and the principal observing sites used during the total solar eclipses of 1868 (red dots), 1871 (green diamonds) and 1898 (purple stars) (map: Wayne Orchiston).

Table 2: A list of the various 22 January 1898 eclipse parties.

No.	Site	Nation	Party	Reference(s)
1	Viziadurg	Britain	Lockyer	Lockyer et al. (1904)
2	Jeur	India	College of Science, Poona	Naegamvala (1898; 1902)
3		Japan	Tokyo University	Terao and Hirayama (1910)
4		USA	Lick Observatory	Campbell (1898; 1900a; 1900b); Orchiston and Pearson (2017)
5	Vangi	USA	Chabot Observatory	Burckhalter (1898)
6	Talni	Britain	British Astronomical Association	Maunder (1899)
7	Pulgaon	Britain	Joint Permanent Eclipse Committee	Hills and Newall (1898)
8	Ghoglee	Scotland	Astronomer Royal of Scotland	Copeland (1898)
9	Sahdol	Britain	Astronomer Royal	Christie (1898)
10	Buxar	Britain	British Astronomical Association	Maunder (1899)
11	Dumraon	India	St. Xavier's College, Calcutta	De Campigneulles (1899); De Campigneulles and Josson (1898)
12		India	Survey of India	

slit spectroscope, a two-prism quartz-calcite camera, and a single-prism quartz-calcite camera (Figure 15).

(3) A 12-inch coelostat with a 6-inch achromatic lens, serving as a coronograph.
(4) A 4-inch portrait lens, serving as a coronograph.
(5) An integrating spectrograph.
(6) An analysing slitless spectroscope.
(7) A telescope to be used to search for prominences.
(8) An objective prism telescope.

Figure 16 gives the layout of the various instruments and structures within the 'eclipse compound'.

On the vital day the sky was clear, and everyone successfully observed the eclipse. Numerous spectra and 40 photographs were taken, many drawings of the corona were made; the variation in temperature during the eclipse was recorded; shadow bands were looked for; and changes in animal and bird behaviour were noted. And all this during a totality that lasted a mere 01m 59 s.

Figure 13: Naegamvālā's Jeur eclipse camp (after Naegamvala, 1898: Plate III). In his *Report* … Naegamvala (1902: 3) described the countryside here as "… flat, almost devoid of trees except for a few scrappy *bábuls* (*Acacia arabica*), and the supply of water was not plentiful." The site was near Jeur railway station, which was serviced from Poona by the Great Indian Peninsula Railway. The location of the eclipse camp was 18° 12′ N, and 75° 12′ E.

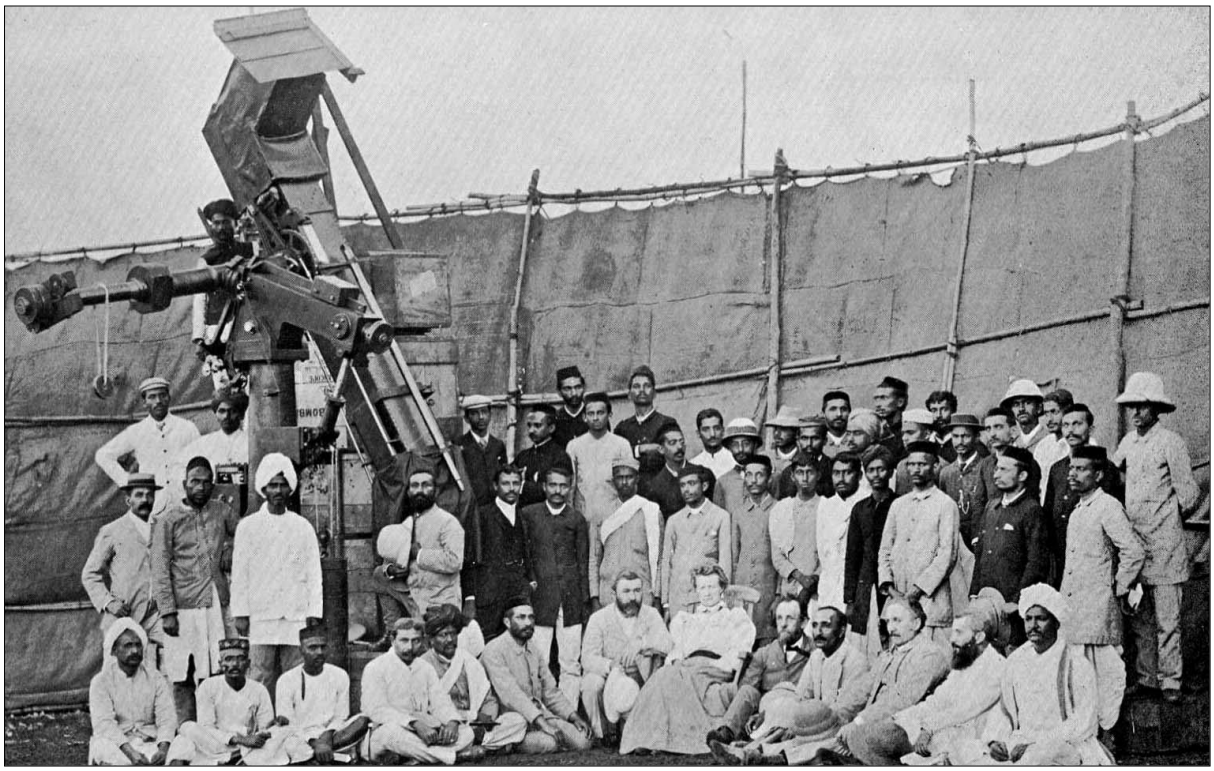


Figure 14: Professor K.D. Naegamvala's Eclipse Team; Naegamvala is seated fourth from the right. The 6-inch prismatic camera is at the rear on the left side (after Damania, 2008: 60).

Here is Fr. Haan's account of events, as communicated by him to the *Bombay Examiner* newspaper:

> Just before totality I could still see the bright lines, but not as distinctly as before. I kept my eye fixed on one part of the spectrum: a group of lines between 500 and 505 wavelengths.
>
> The flash is the moment when the continuous spectrum of the Sun disappears, and the dark lines become bright throughout.
>
> When the flash set in only three-fourths of the lines in the group upon which I had fixed my eye were bright.
>
> Most fortunately, Prof. Naegamvala

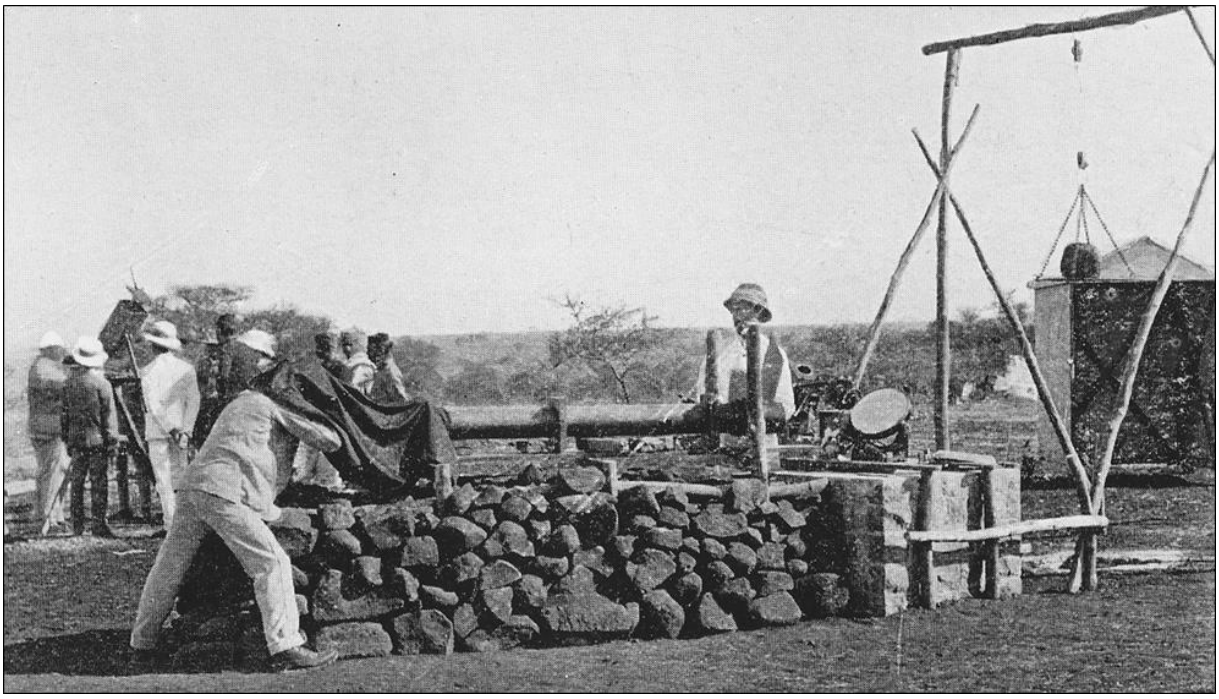


Figure 15: A photograph of Naegamvālā's horizontal photoheliograph, showing the 12-inch heliostat that was driven to track the Sun, and the tube that led to the spectrograph, which was located under the black cloth cover (after Maunder 1899: 81).

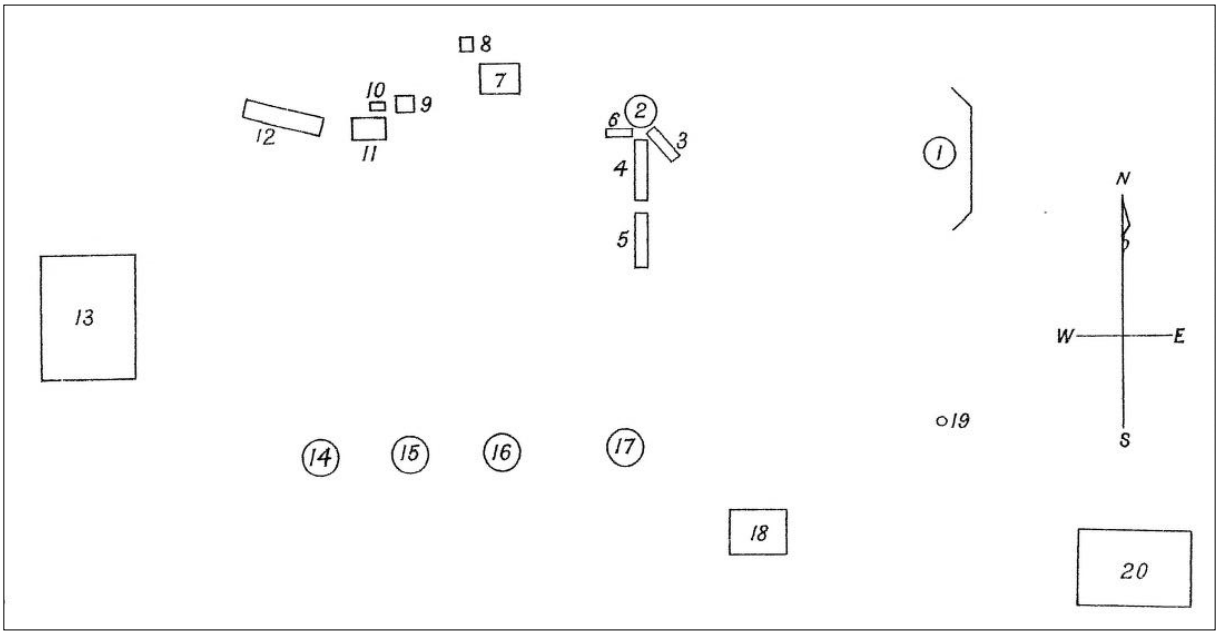


Figure 16: Layout of the eclipse camp. Key: 1 = 6-inch prismatic camera (with wind break); 2 = siderostat; 3 = single spar prism; 4 = 8-inch lens; 5 = slit spectroscope; 6 = two prisms spar; 7 = seconds clock; 8 = 4-inch coronagraph; 9 = well for clock weight; 10 = clock of coelostat; 11= coelostat; 12 = 6-inch coronagraph; 13 = meteorological hut; 14 = slitless analysing spectroscope; 15 = 3-inch telescope; 16 = prismatic telescope; 17 = integrating spectrograph; 18 = darkroom; 19 = Director's seat; 20 = workshop (after Naegamvala, 1902: Plate IV).

has succeeded in the most difficult task of taking a photograph at this important moment. This will no doubt be of the greatest use, for it is very difficult for any observer to see a weak thin line at the side of a bright one, especially when the time for observation is less than a second, as the duration of the flash seemed to be to me.

After the flash there was complete darkness; only the bright arcs of D3 and F remained visible, and in the middle of

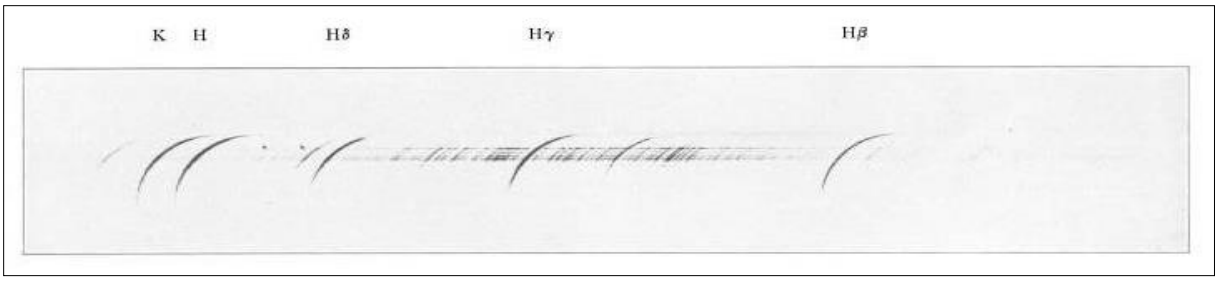


Figure 17: The photograph of the 'flash' spectrum published by in the *Astrophysical Journal* (after Naegamvala,, 1898).

Figure 18: A composite drawing of the corona based on photographs taken by Naegamvālā's team at Jeur (after Naegamvala, 1902: Frontispiece).

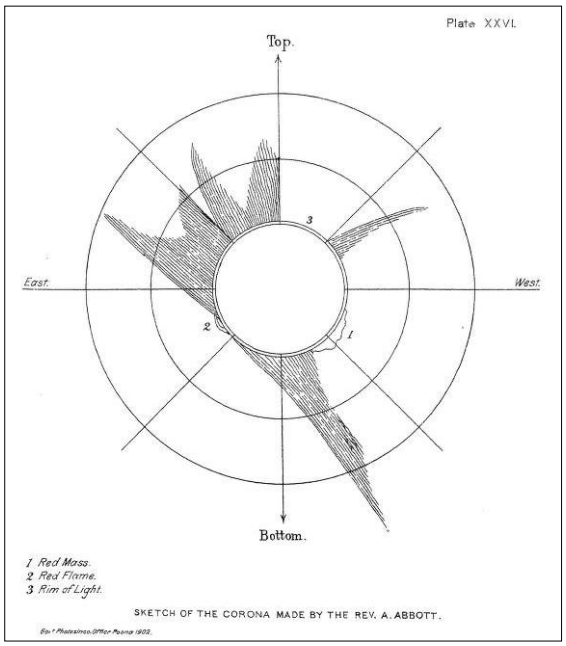


Figure 19: A detailed outline sketch of the corona made by the Reverend A. Abbott at Naegamvālā's Jeur eclipse camp (after Naegamvala, 1902: Plate XXVI).

> the field of vision appeared a luminous, greenish, broad arc, which was at first weak, and then grew steadily in brightness and extension. This was the line 1474, the light of the corona. (Cited in de Campigneulles, 1899: 87–89).

In our opinion, Naegamvālā and his team used this eclipse to make valuable contributions to solar physics in two specific areas: (1) Details of the 'flash spectrum'; and (2) The nature of the corona at this time.

We can presume that Naegamvālā would sympathize with our first choice, since this is precisely what he chose to analyse and write up first before preparing his 1902 monograph about the eclipse. Thus, "Photograph of the spectrum of the "Flash" at the solar eclipse of 21 January 1898" was published in the *Astrophysical Journal* later that very same year (Naegamvala, 1898), and the photograph in question is reproduced here as Figure 17. However, as mentioned by Ansari (2019: 313–314)

> The editor of the *Astrophysical Journal* pointed out to readers that the reproduction "... failed to bring out all the fine lines shown on the original." He also commented that perhaps the most interesting feature of the photograph was the prominence that was shown in two lines, H and Hδ, but was invisible in the H and K and the hydrogen lines (Naegamvala 1898: 121).

The second area where Naegamvālā's eclipse expedition produced useful results was in delineating the nature of the corona at this time. Upon combining the various successful photographs taken, Naegamvala (1902: Frontispiece) then published a composite drawing based on these, and this is shown here as Figure 18. While coronal drawings are often unreliable, the basic form of the corona shown here bears some resemblance to the sketch made at the time by Reverend A. Abbott and reproduced here in Figure 19. January 1898 was near sunspot minimum, but Naegamvala

explains that it is simplistic to assume that the coronal pattern is automatically linked to either sunspot maximum or sunspot minimum. He elaborates:

> A careful examination of the most reliable drawings and photographs since 1860, however, indicates that there are sub-types of coronæ and that the corona of 1898 belongs to one of these. Evidently the form does not change only with the general maximum or minimum period, but with what Newcomb (Astr. Phy. J., Vol.XIII) has called the "mid-phase rising" and "mid-phase falling" epochs, and any abnormal activity of solar spots has also a decided effect on the form ...
>
> An inspection of Plate XX will show that though on the whole there is a great family resemblance between the forms of coronæ at similar phases of solar activity from cycle to cycle, there are many instances of marked variation from a given type. (Naegamvala, 1902: 57–59).

Naegamvala (1902: 60; our italics) then recognises that there is an interesting research project awaiting his attention:

> In a complete investigation of the subject not only the sun-spot frequencies preceding each eclipse by a definite period should be considered, but other indications of solar activity such as faculae and prominences ought to be also taken into account. Moreover, the forms of coronæ as depicted are not all reliable and the same weight cannot be assigned to them all. It is only of late that both the inner corona and its outer extensions at an eclipse have been successfully and adequately photographed. A long series of such photographs taken with identical instruments from eclipse to eclipse alone can contribute to a satisfactory discussion of the problem. However, there seems to be very little room for doubting that the coronal features change in sympathy with the state of absolute solar activity. *In a separate memoir I propose to undertake a further detailed investigation of this most interesting question in solar physics*.

In fact, this foreshadowed memoir never appeared, and no astronomical papers by Naegamvālā appeared after the publication of his 1902 eclipse monograph. So, although this work brought him further international exposure, it also sounded the death-knell for his career as an active astronomer.

We concur with Ansari (2019) that part of the reason for this was Naegamvālā's disillusion over the founding Directorship of Kodaikanal Observatory. Well prior to his retirement as Director of Madras Observatory in 1891, Norman Pogson relentlessly lobbied Government over the establishment of a new high-altitude mountain observatory devoted to solar physics. After Pogson's death his successor, Charles Michie-Smith (1854–1922) took up where Pogson left off, and when the new observatory was approved in 1893 he was appointed founding Director (Kameswara Rao et al., 2014b). Clearly politics was involved here, since Naegamvālā had a far better international reputation in solar astronomy than Michie-Smith did. But Michie-Smith had strong supporters back in England. Ansari (2019: 319) has also pointed out that Naegamvālā was not a 'team-player'. Until the arrival of the 1898 eclipse he tended to work in isolation, and

> … did not have contact with other astronomers working in India, so initially he may have been completely unaware of the developments that led to the establishment of … [Kodaikanal Observatory].

This is certainly possible. So, the 1898 eclipse was 'too little, too late'!

3.4 Langat Singh College Observatory, Muzaffarpur

Muzaffarpur is 70 kilometres north of Patna in Bihar. What interests us here is the Langat Singh College, which was host to an astronomical observatory. The College was established in 1899 and is said to be the oldest institution of higher learning in North Bihar (Langat Singh College; http://www.lscollege.ac.in/).

Named after Babu Langat Singh, the prime mover in its establishment, the College building was modelled after Balliol College at Oxford University. The dome of the astronomical observatory on top of the main building cannot be missed (see Figure 20). In February 1915 the College acquired an equatorially mounted 4-inch refractor from England (Figure 21). A Planetarium is also on campus, near to the Observatory (Figure 22). Originally, the Observatory and the Planetarium were both fully functional, but currently they lack the relevant instrumentation and equipment.

J.N. Sinha (2018), the former Professor of History of Science at the University of Delhi supplied the photographs shown here, and he throws some light on the history of the Observatory:

> … in February 1914, Professor Romesh Chandra Sen of GBB College, as the col-

Figure 20: Langat Singh College (photograph: http://www.lscollege.ac.in/gallery/building; accessed 7 November 2022).

Figure 21: Some of the Astronomy Class of 1949 at the Langat Singh College Observatory (adopted from Sinha, 2018).

Figure 22: The planetarium building at Langat Singh College (adopted from Sinha, 2018).

lege was known then, sought guidance from J. Mitchell to establish an astronomical observatory at the college. An amateur astronomer and the principal of Wesleyan College, Bankura in West Bengal, Mitchell responded with detailed suggestions. Accordingly, the college acquired in February 1915 a telescope from England with a four inch object glass with a 1½ inch finder, a dewshade, and a rack and draw tube. More accessories, including an astronomical clock and a chronograph, were acquired in the coming months.

The observatory was operational by the spring of 1916. On April 7, Mitchell congratulated the college authorities on their "excellent astronomical equipment" that only a few possessed and said he expected them to send him research findings in the future. Soon, they requested the Survey of India in Dehradun for the accurate latitude and longitude of the observatory. In December 1919, the Trigonometrical Survey sent them the coordinates of three points in Muzaffarpur town. Consultations took place also with the Mathematical Instrument Office, Calcutta (now Kolkata), and more instruments and accessories were added in following years.

One knows little about how the observatory functioned after 1933. However, the fact that a planetarium was added to it in 1946 indicates that it was doing well. The planetarium was fairly advanced for its time. The observatory was also used in the BSc astronomy course in which students were taught how to operate the equipment and watch the sky. The position of the stars published in The Statesman was used to make the nightly observations, sources testify."

Post-1970, the planetarium and the observatory began to decline. Most of the equipment became either junk or was lost. The State Government assured the College of support for its restoration, but nothing seems to have come of this.

In 2022, the Langat Singh Observatory and the Planetarium were listed in the "Portal to the Heritage of Astronomy" of the United Nations Educational, Scientific and Cultural Organization (UNESCO), under the Format "IAU - Outstanding Astronomical Heritage" (https://www3.astronomicalheritage.net/index.php/show-entity?identity=217&idsubentity=1):

Langat Singh College Observatory, Kalambagh Rd, B.R. Ambedkar Bihar University, 842001 Muzaffarpur, Bihar, India
Planetarium, Langat Singh College, University Road, B.R. Ambedkar Bihar University, 842001 Muzaffarpur, Bihar, India
Latitude 26°06'50'' N, Longitude: 85°22'44'' E, Elevation 59m above mean sea level."

4 CONCLUDING REMARKS

In the case of Takhtasinghji Observatory royal 'patronage' in the form of financial support was paramount, whereas the Presidency College Observatory in Calcutta and St. Xavier's College Observatory resulted from initiatives taken by expatriate staff with astronomical interests who also had leadership roles in these institutions. In addition, St. Xavier's College Observatory survived, initially, because of strong support provided by a leading Italian Jesuit astronomer.

It is notable that both Takhtasinghji Observatory and St. Xavier's College Observatory were founded to address international developments in astrophysics that were occurring in the 1880s and 1890s. This Indian initiative reflected an enlightened attitude that was rare in other British Asian-Oceanic colonial nations at this time.[4] Note, however, that the founding of Takhtasinghji Observatory resulted directly from an indigenous Indian initiative (through Dr Naegamvala) and local financial support (from Raja Takhtasinghji), while St. Xavier's College Observatory was a joint Jesuit initiative of Fr. Lafont from the College and Italy's Dr. Tacchini from Palermo Observatory and was funded by College supporters and local fund-raising efforts (Chinnici, 1995/1996). But whereas Takhtasinghji Observatory's charter was to further international astrophysics—using suitable instrumentation acquired specifically for this purpose—perhaps Fr. Lafont also hoped that St. Xavier's College could contribute solar data that would help in understanding Indian climatic conditions, and thus assist agricultural production. If this was indeed the case (and currently there is no known evidence one way or the other), Fr. Lafont also would have had an economic or even a socio-political motive for founding his Observatory, and he may not have viewed it solely in the context of solar physics research.

It is notable that of the four observatories discussed here none of them has survived in more-or-less original form through to the present day. With the passage of time the impressive-looking St. Xavier's College Observatory lost its research functions and was demolished, while the much more modest Observatory at Presidency College in Calcutta is regarded as part of the history and heritage of what is now the Presidency University. It is telling, however, that both nineteenth century Calcutta observatories have inspired the recent emergence of modest astronomical facilities at these institutions, to support undergraduate and post-graduate programs in Astronomy and Astrophysics.

Meanwhile, Takhtasinghji Observatory closed following the death of its Indian founder, and the impressive array of instrumentation that had been used for research was transferred to Kodaikanal Observatory. For a long time, the Grubb telescope was not used at Kodaikanal, but in 1951, when Dr. A.K. Das was Director, he had the telescope renovated, and it was used in the International Mars Committee's 1954 opposition program. It has since been used for stellar spectroscopy. Today the renovated 20-inch Grubb reflector is known as the Bhavnagar Telescope and is still used for observational astronomy. It has aptly been described by Kameswara Rao et al. (2014a) as the most travelled telescope in India.

5 NOTES

1. Another important contribution that Fr. Lafont made to Indian science was to assist Dr. Mahendralal Sircar (1833–1904) in founding and developing the Indian Association for the Cultivation of Science in 1876, but this is well documented by Biswas (2000; 2001) and lies outside the scope of this paper.
2. The College of Science was founded in 1854, and was renamed the College of Engineering in 1911. It is the third oldest engineering college in Asia (see www.coep.org.in).
3. In 1897, the 16½ inch mirror was replaced by a 20-inch mirror.
4. For Australia see Orchiston et al. (2017) and for New Zealand see Orchiston and Hearnshaw (2017). Of other Asian British colonies, Hong Kong had an observatory that focussed solely on meteorology and time-keeping (McKeown, 2011) as did Singapore—but in a much more modest fashion (Williamson and Wilkinson, 2017). Surprisingly, Malaya lacked an observatory (Williamson, 2015). Given the over-abundance of typhoons (referred to elsewhere as cyclones or hurricanes) in East and South Asia, cyclone alerts and associated research formed one of the primary roles at not only Hong Hong Observatory, but also Zikawei Observatory (e.g. see Zhu, 2023) and Manila Observatory (e.g. see Alverez, 2023) set up by the

Jesuits on the Chinese coast and in the Philippines, respectively (Udias, 2003).

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7 REFERENCES

Alvarez, K.C., 2023. Observing the heavens, marking time: the astronomical work of the *Observatorio Meteorológico de Manila*, later reorganized as the Philippine Weather Bureau, 1891–1945. *Journal of Astronomical History and Heritage*, 26(1), 9–30.

Ansari, S.M.R., 1985. Introduction of modern Western astronomy in India during 18-19 centuries. *Indian Journal of History of Science*, 20, 363–402.

Ansari, S.M.R., 2000. Introduction of modern Western astronomy in India during 18-19 centuries. In Sen, S.N., and Shukla, K.S. (eds.), *History of Astronomy in India*. New Delhi, Indian National Science Academy. Pp. 395–453.

Ansari, S.M.R., 2019. K.D. Naegamvala: the founder of the first astrophysical observatory in India. In Orchiston, Sule and Vahia, 307–324.

Basu, B.D., 1867. *History of Education in India Under the Rule of the East India Company*. Calcutta, Modern review Office.

Bhattacharya, D., Chakravarty, R., and Roy, R.D., 1989. A survey of Bengali writings on science and technology. *Indian Journal of History of Science*, 24, 8–66.

Biswas, A.K., 1994. Father Eugene Lafont and the scientific activity of St Xavier's College. *Indian Journal of History of Science*, 29(1), 77–88.

Biswas, A.K., 2000. *Gleanings of the Past and the Science Movement: in the Diaries of Drs Mahendralal and Amritlal Sircar*. Calcutta, The Asiatic Society.

Biswas, A.K., 2001. *Father Eugene Lafont of St. Xavier's College, Kolkata and the Contemporary Science Movement*. Calcutta, The Asiatic Society.

Brodrick, J., 1952. *Saint Francis Xavier (1506–1552)*. London, Burns, Oates & Washbourne Ltd.

Burckhalter, C., 1898. A general account of the Chabot Observatory-PIERSON eclipse expedition to India. *Publications of the Astronomical Society of the Pacific*, 10, 203–212.

Campbell, W.W., 1898. A general account of the Lick Observatory-Crocker Eclipse Expedition to India. *Publications of the Astronomical Society of the Pacific*, 10, 127–140.

Campbell, W.W., 1900a. Observations of the second and third contacts at the solar eclipse of 1898 January 22, in India. *Astronomical Journal*, 20, 144–145.

Campbell, W.W., 1900b. Some spectroscopic results obtained at the Indian eclipse of the Lick Observatory-Crocker Expedition. *Astrophysical Journal*, 11, 226–233.

Chinnici, I., 1995/1996. An "Italian" observatory in India: the history of the Calcutta Observatory. *Studies in History of Medicine & Science*, 14(1-2), 91–115.

Christie, W.H.M., 1897. Letter to K.D. Naegamvala, dated 6 August. In RGO Archives, Cambridge University Library.

Christie, W.H.M., 1898. Report on the 1898 Solar Expedition to India. *Proceedings of the Royal Institution* (London), 15, 810–814.

Claridge, G.C., 1937. Coronium. *Journal of the Royal Astronomical Society of Canada*, 31, 337–346.

Copeland, R., 1898. Total solar eclipse of January 22 1898. Report on observations made at Ghoglee, Central Province. *Proceedings of the Royal Society*, 64, 21–26.

Cottam, S., and Orchiston, W., 2015. *Eclipses, Transits and Comets of the Nineteenth Century: How America's Perception of the Skies Changed*. Cham (Switzerland), Springer.

Damania, A.B., 2008. Professor Kavasji Dadabhai Naegamvala (1857-1938) pioneering Paris astronomer. *Fezana Journal*, 60–62.

De Campigneulles, V., 1899. *Observations Taken at Dumraon, Behar, India During the Eclipse of the 22nd January 1898*. London, Longmans, Green, and Co.

De Campigneulles, V., and Josson, H., 1898. *The Total Solar Eclipse on Jan. 22, 1898*. Calcutta, Thacker, Spink & Co.

De Penaranda, A., 1891. The transit of Mercury. *Monthly Notices of Royal Astronomical Society*, 51, 503.

Deslandres, H., and Hale, G.E., 1896. Observations de l'eclipse totale du Soleil du 16 Avril, 1893. *Astrophysical Journal*, 4, 160–173.

Gangooly, P.L., 1906. The Calcutta Observatory. *The Observatory*, 29, 66.

Gariboldi, L., 2014. Tacchini, Pietro. In Hockey, T. *et al*. (eds.), 2014. *Biographical Encyclopedia of Astronomers. 2nd Edition*. New York, Springer. Pp. 2120–2122.

Ghosh, S., 2019. Scientific activities of Fr. Alphonso De Penaranda: a Jesuit priest in the late nineteenth century. *Indian Journal of History of Science*, 54(2), 215–217.

Glass, I.S., 1997. *Victorian Telescope Makers: The Lives and Letters of Thomas and Howard Grubb*. Bristol, Institute of Physics.
Grünwald, A., 1887. On the remarkable relationships between the spectrum of water-vapour and the line-spectra of hydrogen and oxygen, and on the chemical structure of the two latter, and their dissociation in the sun's atmosphere. *Philosophical Magazine Series 5,* 24(149), 354–367.
Hearnshaw, J., and Orchiston, W., 2017. The development of astronomy and emergence of astrophysics in New Zealand. In Nakamura and Orchiston, 581–621.
Hills, E.H., and Newall, H.F., 1898. Total solar eclipse of 1898, January 22. Preliminary Report on the observations made at Pulgaon, India. *Proceedings of the Royal Society of London*, 64, 43–61.
Kameswara Rao, N., Vagiswari, A., and Louis, C., 1984. Father J. Richaud and early telescope observations in India. *Bulletin of the Astronomical Society of India*, 12, 81–85.
Kameswara Rao, N., Vagiswari, A., and Birdie, C., 2014a. Bhavnagar Telescope: the most widely travelled telescope in the country. *Current Science*, 106(4), 617–619.
Kameswara Rao, N., Vagiswari, A., and Birdie, C., 2014b. Charles Michie Smith – founder of the Kodaikanal (Solar Physics) Observatory and beginnings of physical astronomy in India. *Current Science*, 106, 447–467.
Kapoor, R.C., and Orchiston, W., 2023. Colonial astronomy as an element of empire in British India. *Journal of Astronomical History and Heritage*, 26(1), 113–158.
Katti, M., 2022. Two Jesuits who introduced modern education in India. Father Charles Racine and Father Eugene Lafont. *Bhāvanā. The Mathematics Magazine*, 6(2) (https://bhavana.org.in/two-jesuits-who-introduced-modern-education-in-india/; accessed 29 February 2024).
Keay, J., 1991. *The Honourable Company: A History of the British East India Company*. London, HarperCollins.
Kochhar, R.K., 1991. French astronomers in India during the 17th–19th centuries. *Journal of the British Astronomical Association*, 101(2), 95–100.
Kochhar, R.K., and Narlikar, J.V., 1995. *Astronomy in India: A Perspective*. New Delhi, Indian National Science Academy.
Kochhar, R.K., and Orchiston, W., 2017. The development of modern astronomy and emergence of astrophysics in India. In Nakamura and Orchiston, 705–770.
Lawson, P., 1993. *The East India Company: A History*. London, Longman.
Lockyer, N., 1898. *Report on Indian Observatories and their Organisation*. Printed report dated 15 May, 44 pp. Available in the India Office Library, London, call number IOR-L/E/7/425.
Lockyer, N., Chisholm-Batten, Captain, and Pedler, A., 1904. Total eclipse of the Sun, January 22, 1898.—Observations at Viziadrug. *Memoirs of the Royal Astronomical Society*, 54, A1–A78.
MacKeown, K., 2011. *Early China Coast Meteorology: The Role of Hong Kong*. Hong Kong, Hong Kong University Press.
Majumdar, R.C. (ed.), 2007. *British Paramountcy and Indian Renaissance: The History and Culture of the Indian People*, *Volume X*. Bombay, Bharatiya Vidya Bhavan.
Maunder, E.W. (ed.), 1899. *The Indian Eclipse 1898. Report of the Expeditions Organized by the British Astronomical Association to Observe the Total Solar Eclipse of 1898, January 22*. London, Hazell, Watson and Viney.
Naegamwala, K.D., 1888. Observatories. *Observatory*, 11, 438.
Naegamwala, K.D., 1891a. Observations of the transit of Mercury, 1891, May 9. *Monthly Notices of the Royal Astronomical Society*, 51, 501–502.
Naegamvala, K.D., 1891b. On the character of the chief line of the Nebula in Orion. *Monthly Notices of the Royal Astronomical Society*, 51, 442–443.
Naegamvala, K.D., 1892. Notes on the spectrum of the great sunspot group of Feb. 1892. *Monthly Notices of the Royal Astronomical Society*, 52, 424–426.
Naegamvala, K.D., 1898. Photograph of the spectrum of the "flash" made by Professor K.D. Naegamvala at the eclipse of January 21, 1898. *Astrophysical Journal*, 8, 120–121.
Naegamvala, K.D., 1902. *Report on the Total Solar Eclipse of January 21-22, 1898, as Observed at Jeur in Western India.* Bombay, Government Central Press [Publications of the Maharaja Takhtasingji Observatory, Poona. Vol. I].
Nakamura, T., and Orchiston, W., (eds.), 2017. *The Emergence of Astrophysics in Asia: Opening a New Window on the Universe*. Cham (Switzerland), Springer.
Namboodiry, U., 1995. *St. Xavier's, the Making of a Calcutta Institution*. Calcutta, Viking.
Narliker, J.M., 2003. *The Indian Scientist from Vedic to Modern Times: The Scientific Edge*. Harmondsworth Penguin.
Nath, B.B., and Orchiston, W., 2021. Norman Robert Pogson and the observation of the total solar eclipse of 1868 from Masulipatam, India. *Journal of Astronomical History and Heritage*, 24, 629–651.
Nurullah, S., and Naik, J.P., 1943. *History of Education in India During the British Period*. Bombay, Macmillan.
Orchiston, W., and Pearson, J., 2017. American observations of the 22 January 1898 total solar eclipse from Jeur, India. In Nakamura and Orchiston, 795–814.
Orchiston, W., Clark, B.A.J., Frew, D., and Andropoulos, J., 2017. The development of astronomy and the foundations of astrophysics in Australia. In Nakamura and Orchiston, 395–452.

Orchiston, W., Sule, A., and Vahia, M.N., (eds.), 2019. *The Growth and Development of Astronomy and Astrophysics in India and the Asia-Pacific Region: ICOA-9, Pune, India, 15-18 November 2016.* New Delhi, Hindustan Book Agency and Springer Singapore.

Orchiston, W., Orchiston, D.L., George, M., Soonthornthum, B., Gislén, L., Débarbat, S., and Husson, M., 2019. The role of eclipses and European observers in the development of 'modern astronomy' in Thailand. In Orchiston, Sule and Vahia, 173–216.

Orchiston, W., Dumon, P., Gislén, L., Orchiston, D.L., George, M., Launay, F., Débarbat, S., Husson, M., and Soonthornthum, B., 2021. Father Antoine Thomas and the birth of 'Modern Astronomy' in Thailand. In Orchiston, W., and Vahia, M. (eds.), *Exploring the History of Southeast Asian Astronomy: A Review of Current Projects and Future Prospects and Possibilities*. Cham (Switzerland), Springer. Pp. 225–252.

Orchiston, W., and Kapoor, R.C., 2023. Indian initiatives to establish 'Western' astronomical observatories prior to Independence. 1: The aristocrats. *Journal of Astronomical History and Heritage*, 26(4), 923–952.

Pallt, C., 2000. Calcutta: the bridgehead of national science in Bengal, 1876-1916. In Sehgal, et al., 89–97.

Pigatto, L., and Zanini, V., 2001. Spectroscopic observations of the 1874 transit of Venus: the Italian party at Muddapur, eastern India. *Journal of Astronomical History and Heritage*, 4(1), 43–58.

Presidency College, 1955. *Presidency College, Calcutta, Centenary Volume 1955*, Superintendent, Government Printing, West Bengal Government Press Alipore, West Bengal.

Raina, D., 2000. Lamenting the past, anticipating the future: a chronology of popular science writing in India (1850-1914). In Sehgal et al., 54–64.

Sehgal, N.K., Sangwan, S., and Mahanti, S. (eds.), 2000. *Uncharted Terrains: Essays on Science Popularisation in Pre-Independence India*. New Delhi, Vigyan Prasar.

Sen, J., 2014. *Astronomy in India, 1784–1876*. London, Pickering and Chatto.

Sharma, H.D., 2002. *Raja Ram Mohan Roy: The Renaissance Man*. New Delhi, Rupa & Co.

Sheehan, W., and Westfall, J., 2004. *The Transits of Venus*. Amherst, Prometheus Books.

Shi, Y., 2020. Chinese astronomy in the time of the Jesuits: studies following *Science and Civilisation in China*. *Cultures of Science*, 3(2), 77–84.

Sinha, J.N., 2018. An observatory in Muzaffarpur, which had "excellent astronomical equipment", has been allowed to go to rack and ruin and sink into oblivion, Frontline, https://frontline.thehindu.com/science-and-technology/article25166623.ece/amp/ .

Sotome, K., 1911. Talcott-Horrebow Method of determining Latitude made applicable to a small Theodolite, *Astronomische Nachrichten*, 187, 337–340.

Tacchini, P., 1875. *Il Passaggio di Venere sul Sole del 8-9 Dicembre 1874*. Palermo, Palermo Observatory.

Terao, H., and Hirayama, S., 1910. Report on the Total Solar Eclipse of the Sun observed at Jeur, in Western India on January 22, 1898. *Annales de l'Observatoire Astronomique de Tokyo,* III(1).

Udias, A., 1994. Jesuit astronomers in Beijing, 1601–1805. *Quarterly Journal of the Royal Astronomical Society*, 35, 463–478.

Udias, A., 2003. *Searching the Heavens and the Earth: The History of Jesuit Observatories*. Dordrecht, Kluwer Academic Publishers.

Udias, A., 2015. *Jesuit Contribution to Science: A History*. Cham (Switzerland), Springer.

Williamson, F., 2015. Weathering the British Empire: meteorological research in the early nineteenth-century Straits Settlements. *British Journal for the History of Science*, 48, 475–492.

Williamson, F., and Wilkinson, C., 2017. Asian extremes: experience, exchange and meteorological knowledge in Hong Kong and Singapore c.1840–1939. *History of Meteorology*, 8, 159–178.

Woolf, H., 1959. *The Transit of Venus: A Study of Eighteenth-Century Science*. Princeton, Princeston University Press.

Zhu, M., 2023. Fathers to be blamed: media and the public accountability of Zikawei Observatory's typhoon warnings in treaty port Shanghai. *Journal of Astronomical History and Heritage*, 26(1), 83–96.

Professor Wayne Orchiston was born in Auckland (New Zealand) in 1943, and has BA First Class Honours and PhD degrees from the University of Sydney. He is employed by the University of Science and Technology of China in Hefei as the Co-editor of the *Journal of Astronomical History and Heritage*. He is also an Adjunct Professor of Astronomy in the Centre for Astrophysics at the University of Southern Queensland (USQ) in Toowoomba, Australia. Formerly, Wayne worked at observatories, research institutes and universities in Australia, New Zealand and Thailand. Over the past two decades he has supervised more than 35 Master of Astronomy and PhD history of astronomy research projects through three different Australian universities.

Wayne has wide-ranging research interests and more than 500 publications, mainly about historic transits of Venus; historic solar eclipses; historic telescopes and observatories; the emergence of astrophysics; the history of cometary and meteor astronomy; the astronomy of James Cook's three voyages to the Pacific; amateur astronomy and the amateur–professional interface; the history of meteoritics; Indian, Southeast Asian and Māori ethnoastronomy; and the history of radio astronomy in Australia, France, India, Japan, New Zealand and the USA. About 20 of these publications deal with aspects of Indian astronomy.

Recent books by Wayne include *Exploring the History of New Zealand Astronomy …* (2016, Springer); *John Tebbutt: Rebuilding and Strengthening the Foundations of Australian Astronomy* (2017, Springer); *The Emergence of Astrophysics in Asia …* (2017, Springer, co-edited by Tsuko Nakamura); *Exploring the History of Southeast*

Asian Astronomy … (2021, Springer, co-edited by Mayank Vahia) and *Golden Years of Australian Radio Astronomy: An Illustrated History* (2021, Springer, co-authored by Peter Robertson and Woody Sullivan). In addition, Wayne has edited or co-edited a succession of conference proceedings.

Since 1985 Wayne has been a member of the IAU, and he is the Immediate Past President of Commission C3 (History of Astronomy). In 2003 he founded the IAU's Historical Radio Astronomy Working Group, and is the current Radio Astronomy Subject Editor for the Third Edition of Springer's *Biographical Encyclopedia of Astronomers*. He also founded the IAU Working Group on Historic Transits of Venus, is the Founding Chair of the History & Heritage Working Group of the SE Asian Astronomy Network, and is the founding Director of the Historical Section of the Royal Astronomical Society of New Zealand.

In 1998 Wayne co-founded the *Journal of Astronomical History and Heritage,* and was the Managing Editor until 31 July 2022 when he passed ownership of the journal to the University of Science and Technology of China. In 2013 the IAU named minor planet 48471 'Orchiston', and in 2019 he and Dr Stella Cottam were co-recipients of the American Astronomical Society's Donald E. Osterbrock Book Prize for their 2015 Springer book, *Eclipses, Transits and Comets of the Nineteenth Century: How America's Perception of the Skies Change*d. In 2023 Wayne was elected an Honorary Member of the Royal Astronomical Society of New Zealand, and Springer published the following Festschrift: Gullberg, S., and Robertson, P. (eds), *Essays in Astronomical History and Heritage: A Tribute to Wayne Orchiston on His 80th Birthday*. In January 2024 Wayne and Darunee Lingling Orchiston attended the Winter Meeting of the American Astronomical Society in New Orleans, where he was presented with the 2024 Le Roy E. Doggett Prize for History of Astronomy.

Professor Ramesh Kapoor completed a PhD at Agra University in 1980, but had begun his career as an observational astronomer in 1971 at the Uttar Pradesh State Observatory (now Aryabhatta Research Institute of Observational Sciences, ARIES) at Nainital. His main interest at that time was flare stars. From March 1974 until September 2010 he was with the Indian Institute of Astrophysics (IIA) in Bengaluru, where he worked on various topics in relativistic astrophysics: observational aspects of black holes, white holes, quasars, pulsars, etc. He has published in peer-reviewed journals and presented papers at national and international conferences.

He participated as an observer and organizer in IIA solar eclipse expeditions in 1980, 1983, 1995, 1999, 2009 and 2010; apart from Indonesia in 1983, all of these were in India. He also travelled to Columbia (South Carolina) to observe the eclipse of 2017 and to La Higuera (Chile) for the eclipse of 2019.

Ramesh's current interest is the history of astronomy in India. "Comet Tales from India", an ongoing project since 2009, seeks to record comets from the Indian region reported in publications, manuscripts and on inscriptions from antiquity until the nineteenth century where available data, however minimal, permit identification of the comet. The resulting research has been presented in journals and at conferences. His new project, "Eclipse Tales from India", seeks to trace total and annular solar eclipses mentioned in Indian written works or in inscriptions from antiquity until the nineteenth century.

All along, Ramesh has been active in promoting astronomy, with many popular articles published in national dailies and science magazines. He frequently interacts with the print and the electronic media on diverse scientific topics that are of interest to the general public. He has also published on Indian systems of medicine.

Ramesh has been a member of the International Astronomical Union since 1985; a Life Member of the Astronomical Society of India since 1973; an Associate of the National Institute of Advanced Studies (NIAS, IISc) since 2002; and a COSPAR Commission E Associate since 2005. His ORCID iD is https://orcid.org/0000-0002-4858-0476.