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***History of Indian Astronomy. A Handbook*, edited by K. Ramasubramanian, Aniket Sule and Mayank Vahia. (Science and Heritage Initiative Indian Institute of Technology, and Tata Institute of Fundamental Research, Mumbai, 2016). Pp. x + 662. ISBN 978-81-923111-9-7 (hard cover), 170 × 247 mm (for the price, email mnvahia@gmail.com).**

The other book received by those who attended ICOA-9 in Pune, India, in November 2016 was a handsome 672-page volume, edited by three luminaries of Indian astronomical history, Professor K. Ramasubramanian (Indian Institute of Technology), Dr Aniket Sule and Professor Mayank Vahia (both from the Tata Institute of Fundamental Research).

As the 'blurb' on the back cover indicates,

This volume is a compilation of twenty-one thematic articles that provide a glimpse of the origin and development of astronomy in India from the Vedic period till the beginning of 20th century. These articles have been contributed by a galaxy of renowned scholars.

After an introductory chapter titled "Roots of Indian astronomy" by Mayank Vahia, Nisha Yadav and Srikumar Menon where they review astronomical basics before discussing "Astronomy and civilisation" in an Indian context, the archaeologist, Riza Abbas, writes about "Rock art and astronomy in India". Those familiar with international developments in rock art studies will be aware of the challenges involved in assigning astronomical meaning to different motifs, so I was very surprised to read that Joglekar et al. (2006) have found evidence of a prehistoric supernova explosion depicted on an engraved stone slab at Burzahom, and that "In this study they have scientifically proved that this would be first record of a sky map drawn to record a particular event." (page 48). Even though I allowed the publication of a paper about this same engraving in this journal (see Iqbal et al., 2009) in order to encourage lateral thinking and discussion, in fact this engraving is controver-

sial, and other equally-compelling interpretations can be proposed for it that have nothing whatsoever to do with a supernova.

In Chapter 3 Srikumar Menon discusses "Megalithic astronomy in India", where he stresses their relative abundance in southern India (see the distribution map on page 65). Menon concludes:

Despite nearly two centuries of academic attention being focussed on them, the Indian megaliths still have a lot of unanswered questions centred on them ...

Stone alignments in different parts of southern India and Vidarbha seem to hold some promise of astronomical sightlines incorporated as part of their design and layout. (page 81).

We then move from archaeoastronomy to ethnoastronomy (Chapter 4), where Mayank Vahia and Ganesh Halkare talk about "Astronomy of tribals of central India". Although regretting the use of the term 'tribals' in lieu of 'tribes', I found this chapter interesting, although most of it was familiar to me thanks to a series of research papers that the authors had already published (and several of them in this journal). As Vahia and Halkare point out, "... several Indian tribes that have been isolated from the mainstream have their own understanding of the sky and constellations." (page 85). Over the next 11 pages or so they discuss indigenous constellations in different areas of the sky and their terrestrial associations (ecological activities, the monsoon, etc.), along with the Milky Way, Solar System objects, eclipses and creation myths. The authors hope that this chapter "... will encourage researchers in other parts of the country to undertake similar studies of the astronomy of the tribes of India before modernity completely overwhelms them." (page 104).

Then follow two chapters about Vedic astronomy, and I found the first of these, by R.N. Iyengar (Jain University, Bangalore), captivating, where he discovers references to eclipses, comets, meteorite impacts, and the shifting of the 'pole star' in Vedic texts. However, these references are not always obvious since

... Vedic culture personified celestial objects and their actions. Hence the texts carry a background that has to be deciphered for extracting the archaic models of the visible sky." (page 108).

As with those who wrote earlier chapters in this book, Iyengar draws on his own earlier publications, but then brings his long 63-page chapter up-to-date by including considerable new material.

Kak's much shorter chapter follows, and this presents a useful overview of the relationship

between Vedic astronomy, ritual and temple design.

Those with an interest in calendars will value Chapter 7, where two retired Indian astronomers, S.K. Chatterjee and A.K. Chakravarty discuss the “Indian calendar from post-Vedic period to 1900 CE”. Their long and detailed account (49 pages) is a partly-revised version of a paper that they first published in 2000.

An old Japanese friend of mine, Dr Yukio Ohashi, is the author of the next chapter, which is titled “The mathematical and observational astronomy in traditional India”. This long chapter is a reprinted version of a paper that was originally published in 2009 so was in little need of up-dating. Those with an interest in Vedic astronomy and Indian calendars also will find much of interest in this 77-page chapter, which in fact ranges beyond India to also discuss—albeit briefly—Greek, Islamic, Tibetan, Chinese and even Thailand and Burmese astronomy. Immediately prior to presenting an invaluable 9.5-page list of references, Yukio winds up his informative chapter in a charming way: “I hope some readers of my paper will become future researchers, and they will make my paper outdated by their own research works!”

In Chapter 9, M.S. Sriram, M.D. Srinivas and K. Ramasubramanian review “The traditional Indian planetary model and its revision by Nīlakaṇṭha Somayājī”, while M.S. Sriram discusses “Bhāskarācārya’s astronomy” in Chapter 10.

“Lunar and solar eclipse procedures in Indian astronomy” by P. Venugopal, K. Rupa and S. Balachangra Rao comprises Chapter 11 while the same authors but in revised order (Balachangra Rao, Venugopal and Rupa) discuss “Transits and occultations in Indian astronomy in the following chapter. From ca. 505 CE Indian astronomers knew the causes of solar and lunar eclipses and in Chapter 11 the circumstances of the eclipses were computed “... according to Bhāskara II’s *Karaṇakutūhala*, *Grahalāghava* and Improved *Siddhāntic* procedures ISP.” (page 408). Meanwhile, similar procedures were used to compute transits and occultations, but although planetary conjunctions are discussed in most traditional textbooks on Indian astronomy transits of Mercury and Venus are not explicitly mentioned. The authors therefore proceed to outline a procedure developed by Professor T.S. Kuppanna within the framework of Siddhāntic astronomy, using the 2004 and 2012 transits as examples.

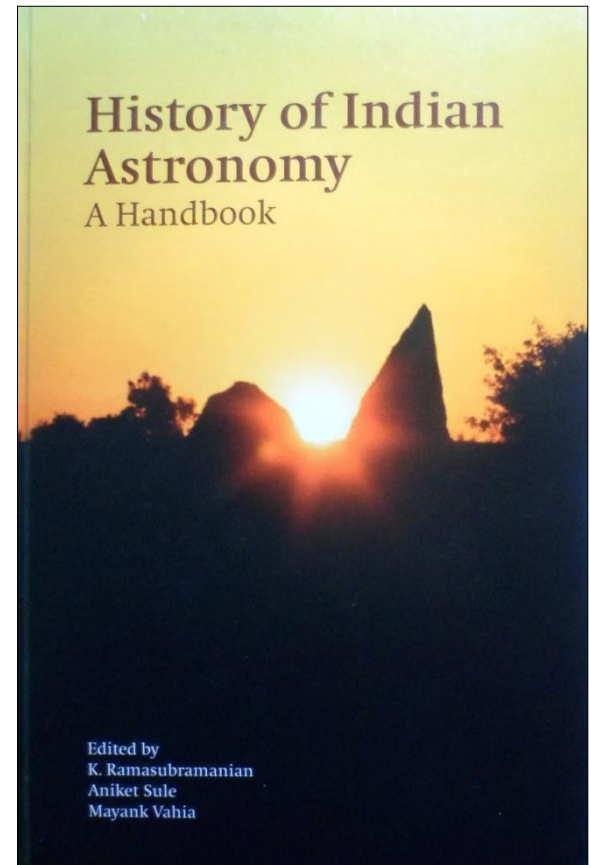
The next chapter is titled “An overview of the *vākya* method of computing the longitudes of the sun and moon” and was written by Venketeswara Pai, K. Ramasubramanian, S. Sriram and M.D. Srinivas, and aims “... to highlight the ingenuity and beauty of the *vākya*

method of planetary computations.” (page 430).

Continuing the computational astronomy theme, Chapter 14 by Clemency Montelle (from New Zealand) and K. Ramasubramanian discuss “The numerical tables related to eclipse computation in the *Parvadvayasādhana* of Mallāri”. They point out that the *Parvadvayasādhana*

... is somewhat unusual in the sense that it presents more complex tables having multiple rows and columns in the form of beautiful verses in *śardūlavikrīḍita* metre (19 syllables per quarter). (page 475).

The theme of the book changes notably with Chapter 15, which is about “Indian astronomical



instruments: A descriptive catalogue of extant specimens”, penned by S.R. Sarma. In researching this theme, Sarma says that he

... decided to make a survey of museums and identify pre-modern astronomical and time-keeping instruments. Such a survey, I hoped, would be useful because the actual specimens might help in understanding the brief descriptions of the texts. Conversely, textual knowledge would help in identifying an instrument and in dating its original design. Finally, this combined approach of studying the texts together with instruments would throw better light on trans-cultural exchanges, especially between the Sanskrit and Islamic traditions of instrumentation in the medieval period. (page 478).

In the following 21 pages Sarma presents an assortment of astrolabes, celestial globes, armillary spheres, various types of quadrants, sundials, gnomons, water clocks and other rarer types of instruments of Indian design and construction. On a plaintive note Sarma describes how he made an inventory of the portable astronomical instruments at the Sawai Jai Singh Astronomical Observatory in Jaipur in 1991 and later sent his catalogue to the Observatory's Superintendent, but by the time a new building for the display of these instruments was opened the original Superintendent had retired and the instruments were displayed without proper identification. "It is like a museum displaying a painting by Picasso without any label! It is a great pity." (page 498). I totally agree with him.

The next two chapters in the book were written by B.S. Shylaja, whose name should now be well known to all, thanks to the two preceding book reviews that appear in this issue of this Journal. Chapter 16 is about "Navigation and astronomy". I presume that Shylaja's primary focus is meant to be Indian maritime navigation, but unfortunately she ranges far and wide geographically, discussing the Kerkennah fishermen of Tunisia; Gilbert and Caroline Islanders in the Pacific; Portuguese navigators; Lieutenant James Cook's use of eclipses, Jovian satellite phenomena and the 3 November 1769 transit of Mercury to determine longitude; the Bugis voyagers of Indonesia; and even the Vikings. I have to say that I found this hotchpotch of examples confusing, as much better case studies could have been employed if Shylaja's aim was simply to document the range of techniques used internationally in order to determine latitude and longitude. Then, when we finally put aside these various examples and look just at Indian navigation the pickings are lean and we end up with a rather simplistic account of how certain coastal people from the Subcontinent used astronomy to successfully sail from one place to another. However, variations in the navigational techniques and instruments used at any one time in different coastal regions of the Subcontinent are not discussed, and there is no attempt to trace changes in the techniques and technology that occurred with the passage of time. Various indigenous names for different stars listed on page 508 and 511 are not referenced, while some key references that Shylaja does mention in the text are not listed in the References section (e.g. Grimble, 1931; Leybourn, 1861 and the various papers by Vardarajan). A map of the Subcontinent and adjacent regions of the Indian Ocean would have been helpful for those readers wishing to pin down localities that Shylaja does mention. However, Shylaja seems aware of the limitations of her study when she mentions that the navigational

techniques of some coastal groups have still to be studied. Furthermore, "The study hints at a vast treasure house of astronomical knowledge which is slowly being lost." (page 512), and "... satellite communication systems have now revolutionized the lifestyle in these tiny islands and are slowly wiping out the traditional techniques." Despite these caveats, and although I am vitally interested in this topic and have written on it myself (e.g. see Orchiston, 1998; 2016: Chapters 4–6), I found this to be one of the least rewarding chapters of the book.

Happily, Shylaja has made a better fist of Chapter 17, "Astronomical aspects associated with temples". Temples in India date back more than 2,000 years, and apart from their religious and educational functions some of them also were associated with time-keeping and calendar-making. After reviewing Indian calendars and festivals Shylaja transports us to South Africa, where ceremonies of reputed south Indian origin are still performed by the local inhabitants at specially-constructed places of worship. These reported south Indian-South African cultural links are fascinating and warrant critical examination. The book then returns us to India and the mathematical and astronomical knowledge exhibited by temple-builders across the subcontinent and across the sands of time. Two structures with clear astronomical associations that she reviews in considerable detail are the Vidyāsankara Temple at Śrīrgerī and the Gavi Gaṅgāhareśvara Temple at Bengaluru, although she seems unfamiliar with the paper by Kameswara Rao and Thakur (2011) about the former temple. Shylaja then discusses a number of other temples that exhibit solstice alignments, and then explores the concept of a basic scale that was used in temple construction in southern India. Leading from this is the fascinating idea that the sun temples in some cities—such as ancient Varanasi (see Rana, 2009)—were based on astronomical alignments. Shylaja stresses that her study is still in its infancy, and

A mammoth task lies ahead — we have to decode how the blueprint of the temples were [*sic*] prepared and what were the astronomical aspects that were incorporated. (page 545).

In Chapter 18 we return to astronomical instrumentation—albeit on a gigantic scale—when N. Rathnasree (from the Nehru Planetarium) discusses "The Jantar Mantar observatories of India teaching laboratories of positional astronomy". I found it interesting that one of Jai Singh's objectives when he set up these giant masonry observatories 300 years ago was that "... common citizens could ... make observations on their own ..." (page 552) and this is precisely what Rathnasree has done as part of the outreach program of the Nehru Planetarium.

So, for the first time in 300 years, the Jantar Mantar were used successfully as a teaching laboratory, as illustrated by various photographs and graphs that accompany this chapter. After reading this interesting chapter, I now see the Jai Singh observatories in a totally new light.

The third-last and penultimate chapters in this long but invaluable book were written by Professor Raza Ansari, a long-time colleague through our mutual IAU and ICOA associations. Chapter 19 is titled “Tradition of astronomical sciences in medieval India” and was developed from a paper that Ansari published in 2014 so is totally up-to-date. After some introductory comments, Ansari discusses in sequence the major astronomical features associated with the Sultanate Period (AD 1191–1526) and the Mughul Period (1526–1748), including the contributions made by Babur, Naṣīruddīn Muḥammad Humāyūn, Abul Faṭḥ Jalāluddīn Akbar, Nūruddīn Jahāngīr, Abul Muẓaffar Shahābuddīn Muḥammad Shāhjahān and Roshan Aktar Muḥammad Shāh. As Ansari points out,

During the Mughal period, the constant stream of scholars, crafts men, and artists particularly from Central Asia continued vigorously, and those migrants brought with them knowledge of all natural sciences into India. (page 583).

In an astronomical context, this is well portrayed in this excellent, well-researched and well-referenced chapter, but one key reference that has been published since Ansari wrote this chapter is Kapoor (2015).

Nor does this high standard change in Ansari’s next chapter, “Reception of modern western astronomy in the 18th–19th centuries”, where

... we confine ourselves mainly to Persian-speaking Indian scholars, who came into direct contact with the British scientists, engineers, and doctors. These ideas resulted in an academic interaction and exchange of scientific ideas. Consequently, we present here a brief survey of selected Indo-Persian writings dealing with Modern European Astronomy ... (page 607).

Those selected for this analysis are: Sawā’i Jai Singh, Mīr Muḥammad Ḥusain, Mirzā Abū Ṭālib Khān Iṣfahānī, Ghulām Ḥusain Jaunpūrī, Raja Ratan Singh, Ḥadā’iq al-Nujūm and Tafaddul Ḥusain Khān bin Ikramullāh Khān. But much of this impetus was stifled when the British Colonial Government introduced English as the official language during the nineteenth century.

And so we arrive at the final chapter in this impressive tome, Professor Rajesh Kochhar’s contribution on “The growth of modern astronomy in India, 1651-1960”. I have known Rajesh for several decades, and have been impressed with his writings on the history of Indian astronomy, so I was rather disappointed to discover

that all he chose to do was reprint a paper that originally was published in *Vistas in Astronomy* back in 1991 (and is listed in the references assembled on page 349 in these book reviews). The problem is that while the basic narrative of Indian astronomical history has not changed during this 300-yr period, much additional research has been published. So we certainly can accept Rajesh’s accounts of “Use of the telescope in the 17th century”, “Advent of modern astronomy in the 18th century”, “Madras observatory (1786–1899)”, “The great trigonometrical survey of India ...”, “Lucknow observatory (1831–49)”, “Trivandrum observatory (1837–52)”, “Poona non-observatory”, “19th century positional astronomy – a critique”, “Advent of physical astronomy (1874)”, “Takhtasinghji’s observatory in Poona (1888–1912)”, “Kodaikanal observatory (1899)”, “Nizamiah observatory (1901)” and “Uttar Pradesh state observatory, Nainital (1954)”, but to bring readers up-to-date the books by Launay (2012), Nath (2013) and Sen (2014) need to be consulted, while all of the following research papers contain material that supplements that presented in Kochhar’s chapter: Biswas (1994; 2003); Kameswara Rao et al. (2009; 2011); Kapoor (2011; 2013; 2014); Kochhar (2002); Orchiston et al. (2006); Orchiston and Pearson (2011); Pigatto and Zanini (2001); Rathansree et al., (2012); and Reddy et al. (2007).

After Kochhar’s chapter, the book ends with a 10-page glossary of astronomical terms, but there is no Index.

Notwithstanding my comments about the final chapter, and the absence of an Index, overall this is a wonderful book, with lots of interesting reading. Most of the chapters are well illustrated, and many chapters have long lists of references for those wishing to follow up specific areas of interest. I have no hesitation in recommending this book, and believe that it will long remain a primary reference work for those interested in the history of Indian astronomy.

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