History of Science in South Asia

S. Balachandra Rao, Indian Astronomy: Concepts and Procedures (Bengaluru: M. P. Birla Institute of Management, 2014)

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S. Balachandra Rao, *Indian Astronomy: Concepts and Procedures* (Bengaluru: M. P. Birla Institute of Management, 2014) (New Delhi: Yoda Press, 2015), pp. xiv, 328. ₹ 450.

In addition to being the year in which Dr. S. Balachandra Rao's book *Indian Astronomy: Concepts and Procedures* was published, the year 2014 was marked by the 900th birth-anniversary of one of the most renowned astronomers of Indian history, namely, Bhāskara II (born 1114 CE). It is appropriate that Dr. Balachandra Rao's book, a wonderful contribution to the study of astronomy in India, should appear in a year in which there was a heightened focus on Indian astronomy.

As indicated by its title, the present book deals with the concepts and procedures of Indian astronomy. More specifically, it deals with the concepts and procedures of the classical schools of Indian astronomy, which arose around the middle of the first millennia CE. A brief introduction to the earlier history of astronomy in India, namely, astronomy in the Vedic texts and the *Vedāṅgajyotiṣa* (an ancient Sanskrit text dealing with the determining the correct time for performing various sacrifices), is given (pp. 1–5), but the remainder of the book deals with classical Indian astronomy.

The topics covered in the book are by and large those found in a *siddhānta*; that is, the topics found in a comprehensive treatise of one of the classical schools of Indian astronomy, covering not only the formulae needed for making astronomical calculations but also expounding the theory and the underlying model of the scientific system. The topics include the celestial sphere and its great circles, coordinate systems, time, mean and true positions of the luminaries and planets, lunar and solar eclipses, and conjunctions of heavenly bodies. The book also covers, significantly, the Indian calendar (*pañcāṅga*) and astronomical tables in the Indian astronomical tradition.

It is important to note that the book is not an academic study of Indian astronomy. While Dr. Balachandra Rao's erudition is evident to readers of his book, the book is intended for students and general readers. Its purpose is to generate an awareness of Indian astronomy and proficiency in the computational procedures developed by the tradition over many centuries (p. iv). By this I do not mean to imply that the book is not useful for scholars studying the history of astronomy in India. On the contrary, such scholars will benefit from one of the significant contributions of the book, namely, the carefully worked-out examples found throughout it.

While academic studies present and comment on the formulae given in a source text, the emphasis is rarely on their practical use. Rather, emphasis is put on the exact phrasing of the formula, a theoretical discussion of the formula's

correctness, or a comparison of the formula with similar formulae found elsewhere in the Indian astronomical tradition (or in other traditions, such as Islamic astronomy).

Dr. Balachandra Rao's book, on the other hand, does not proceed chronologically in terms of the historical development of the system, nor does he discuss variations of the formulae in the works of different astronomers. Rather, he presents the formulae clearly and illustrates them with useful examples. Considering the complexity of many of the formulae and methods, simply having access to a correct formulation of particular formula is not sufficient for understanding how it is to be used practically. It takes some practice and experience to become familiar with the system and how the formulae work within it.

The book uses two texts as representatives of Indian astronomy as found in *siddhānta* treatises, namely, the modern *Sūryasiddhānta*, generally dated to the 9th or 10th century CE, and the *Grahalāghava* of Gaṇeśa Daivajña, composed in the early 16th century (p. 14). There are, of course, numerous other excellent texts that could have been used, but the two chosen are good choices. While there are differences between the various texts, if one is able to master the computational system of one text, working with the system of another will not prove too difficult.

To give an example, formulae from Indian astronomy often rely on the so-called "day-group" (Skt. *ahargaṇa*), the number of civil days elapsed since a given epoch is used, where the epoch is a specified time used for astronomical computations. However, given a date in our current calendar, it is not straightforward to compute the number of days elapsed since a given epoch from Indian astronomy (the epoch could be the beginning of the *kaliyuga*, a time period from Indian mythology which began more than 5,000 years ago, or a given historical date used by an astronomer in a text).

Chapter 8 in the book, which covers the *ahargaṇa*, contains many practical examples. Two such examples (p. 62–63) provide practical examples of how to compute the *ahargaṇa* of a given date (April 12, 1991 and December 24, 2010, respectively) when the epoch is the beginning of the *kaliyuga*. Other examples demonstrate how to find the modern date corresponding to a date in the Indian calendar via the *ahargaṇa* (pp. 67–68).

Other examples of useful worked-out procedures include how to practically compute true positions for the luminaries and planets, described in chapters 10–11. The Indian model for planetary motion is complex, involving two epicycles to describe the motion of the five planets known to the Indian astronomers (the model describes the motion of the sun and moon through one epicycle for each). The two epicycles are presented as if independent though in reality they are not. As such, their combination is not obvious and is computationally complicated. The inclusion of the worked-out examples in this case are extremely useful as

they enable the reader to understand how the model works on a deeper level.

Furthermore, the examples of the computations involved with lunar and solar eclipses in chapter 13–14 are equally valuable. These computations involved with a solar eclipse are especially complicated.

Overall, the worked-out examples constitute a significant contribution to the field. It enables the interested reader to get to know the Indian astronomical model at a deeper computational level. At the same time, it does the same for the specialist scholar of Indian astronomy, who can use the book as a reference work to be consulted on computational aspects.

Beyond computational examples, Dr. Balachandra Rao's book makes another important contribution to the study of Indian astronomy in chapter 20, which focuses on astronomical tables in Indian astronomy. The important topic of astronomical tables in Indian astronomy has only recently received significant attention. As such, the discussion in the book is important. Moreover, in addition to merely discussing known tables, Dr. Balachandra Rao reports on new material in the book. More specifically, he managed to procure a manuscript of a text entitled the *Grahagaṇita-padakāni* from a private collection (p. 288). The manuscript belongs to a place named Tyāgarti in Karnataka and the tables are based on the modern *Sūryasiddhānta*.

The book thereby provides a glimpse into how astronomical computations were done in practice at a local level. This glimpse provides a wonderful companion to the material covered previously in the book.

It is also important to note that the book has an extremely useful glossary of technical terms. The glossary has both an "English to Sanskrit" and a "Sanskrit to English" part. The glossary is especially useful for a student working on an Indian astronomical text in the original Sanskrit.

Overall, Dr. Balachandra Rao's book is a real contribution to the field of Indian astronomy. It is recommended for both interested readers and scholars working more seriously with the history of Indian astronomy.

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