Indian Journal of History of Science, 47.2 (2012) 291-296

BOOK REVIEW

K Ramasubramanian & M S Sriram; ***Tantrasaṅgraha of Nīlakaṇṭha Somayājī*****,** Hindustan Book Agency, New Delhi, 2011, 642 pages, ISBN-10: 9380250096

Reviewed by: Anil Narayanan, Consultant, Washington DC, USA. Former scientist, Indian Space Research Organization; Email: anilkn_ban@hotmail.com

Nīlakaṇṭha Somayājī's semi-heliocentric model of planetary motion was developed before Copernicus's revolutionary heliocentric theory. Both are landmarks in the history of world astronomy. Nīlakaṇṭha is indeed an object of pride for Indian science.

Back in the 19th century, Charles Whish of the erstwhile East India Company was the first European to discover the ingenious works of the 'Kerala School of Mathematics and Astronomy', a school that flourished for several centuries in the northern part of Kerala during the medieval period. Since that discovery, there have been speculations about the possible role that this Indian school may have played in the development of European mathematics and astronomy. The transmission of knowledge is thought to have occurred through Jesuit missionaries of Europe, who have been active in Kerala for many hundreds of years.

Was Copernicus influenced by Nīlakaṇṭha? The dates of the two, Nīlakaṇṭha (1444–1544 AD) and Copernicus (1473–1543 AD), are certainly close enough to stir the imagination. It is recognized that Nīlakaṇṭha completed his work in the year 1500 while Copernicusis known to have first mentioned the heliocentric idea in a letter to a friend in 1514, though it took him another 30 years to publish his revolutionary book. Many technical details of Copernicus's system closely resemble the models of earlier Islamic astronomers *Al-Tusi* and *Al-Shatir,* which makes it a certainty that he had access to their works. If so, was Copernicus aware of Nīlakaṇṭha's works too? We do know for certain that Tycho Brahe, who came after Copernicus, developed a semi-heliocentric model that was a replica of Nīlakaṇṭha's model.

Be that as it may, while there are many volumes written about Copernicus and Tycho, very little is known to the public and the scientific community about Nīlakaṇṭha and the Kerala School. Starting in the early 1970s the late Dr. K.V. Sarma made pioneering efforts in unearthing and translating several works of the Kerala School. Towards that objective, the authors of the present volume Prof. Ramasubramanian and Prof. Sriram, who were Dr. Sarma's younger colleagues and followers, and are eminent researchers in their own right, have done a commendable job in bringing forth this translation of Nīlakaṇṭha's most celebrated work – the *Tantrasaṅgraha*.

A distinctive and well-known feature of Nīlakaṇṭha's planetary system is its major deviation from the traditional planetary model, particularly in the handling of the inner planets Mercury and Venus. Nonetheless, upon glancing through the book, the first impression one gets is the similarity in layout and coverage of topics with traditional books of Indian astronomy like the *Sūrya Siddhānta* or *Siddhānta Śiromaṇi*. Thus it appears that though Nīlakaṇṭha made radical changes to the conventional system, he was schooled in and thoroughly imbued with the traditional astronomical framework.

The *Tantrasaṅgraha* has 432 verses in Sanskrit divided into eight chapters.The authors of the present volume have chosen to group these verses by context, under suitable headings, rather than translate each verse separately. This is certainly convenient for the reader. The authors have also used a quadruple-format for the book. Original text in Sanskrit is followed by transliteration in English, which is followed by a direct technical translation of the verses into English and finally an elaborate commentary on the topic with diagrams, references and the like. This format will find favor with researchers as it presents the original verse along with the authors' interpretation of the meaning and etymology of the verse.

The original *Tantrasaṅgraha* has spawned some commentaries and auxiliary works in the past. The most important of these are the *Lagu-vivṛti* and *Yukti-dīpikā* by Śaṅkara Vāriyar (1500 – 1560 AD) and the *Yūkti-bhāṣa* by Jyeṣṭhadeva (1500 – 1575 AD). The authors of the present volume have drawn freely from these commentaries while preparing their translation, which has enriched the book immensely.

The *Introduction* chapter begins by describing the available versions of the *Tantrasaṅgraha* and its various commentaries. This is followed by a brief history of the Kerala School of Mathematics and Astronomy and the contributions by its members. A description of Nīlakaṇṭha and his various works are given. Not many details of his personal life are known other than the name of his clan, his village and his immediate teachers and pupils. At the end of the introduction, each chapter of the book is summarized.

In *Mean-Longitudes* Nīlakaṇṭha lays down the physical and mathematical foundations of his system. It includes various definitions of time, fundamental constants of the universe (mean motions of the planets, stars, etc.) and some basic operations in positional astronomy. The next chapter on *True-Longitudes* deals with procedures for applying corrections to the mean longitude, in order to obtain the true longitude of a heavenly body. It is here that one notices the change from the traditional geocentric model to the semi-heliocentric one. This is followed by the *Gnomonic-Shadow* chapter which is the longest and deals with the amazing astronomical discoveries that one can make using a simple vertical stick and its shadow. The precession of the equinoxes is described here as a trepidation, unlike the older texts where it is said to be a continuous circular motion. This chapter also describes the 'ten problems', which considers the question of determining the remaining two when three out of five astronomical quantities are known.

In the *Lunar-Eclipse* and *Solar-Eclipse* chapters that follow we see procedures to determine all parameters associated with Lunar and Solar eclipses including the instant of time, the longitude and latitude of the Moon and Sun, the duration, the beginning and end of the eclipse, visibility and the effect of declination.

The *Vyatīpāta* chapter deals with a curious phenomenon involving the Sun and the Moon that was considered to be of great astrological significance by the ancients. The next chapter, *Reduction-to-Observation*, presents methods for determining the visibility of planets. The final chapter on *Elevation-of-the-Lunar-Horn* describes the true motion of the Moon and how to find the correct phase and deflection of the horn.

Appendix-A contains an interesting and useful reference to two numeral systems prevalent in Kerala – *Kaṭapayādi* and *Bhūtasaṅkhyā*. The latter is an older system that is used extensively in many traditional texts and

will prove useful to the researcher. Appendices B and C have some basic information on Spherical trigonometry and the various coordinate systems used in astronomy. Appendix-D contains a couple of examples in the solution of 'ten problems' from the *Yūktibhāṣa* and Appendix-E is a derivation of the maximum declinationof the Moon. Appendix-F is an elaborate discussion on the traditional model of planetary motion and its revision by Nīlakaṇṭha.

The *Tantrasaṅgraha*, as the name implies, is a *tantra* text as opposed to a full *siddhānta* or a relatively minor *karaṇa* text. Thus it contains information that is primarily of an algorithmic nature and not of a fully-detailed *siddhāntic* variety. But the present authors have remedied that situation by providing copious explanations and plentiful figures throughout the book. Also included are profuse footnotes, correlated references and appendices, making the book very useful for both novices and experts alike. There is also an elaborate Sanskrit-English technical glossary at the end that should benefit researchers as well as casual readers. At times the authors have been over-zealous it seems, by including Sanskrit text from referred books and translating those as well! However that does not take away but only adds to the value of the book.

It is interesting to note that not only did Nīlakaṇṭha change the traditional geocentric model but he also changed some fundamental working details of the earlier system.While the pulsating-epicycle has been the fundamental mainstay in the traditional model, in Nīlakaṇṭha's system, only the *Manda* epicycles are of the pulsating variety. The *Śīgra* epicycles do not pulsate. Also, the radius (r) of the epicycle at any point is directly proportional to the *hypotenuse* (H)(i.e. r α H). Since H has a period of 360 degrees, so has r. In the traditional model, r has a period of 180 degrees or half that of Nīlakaṇṭha's model.

Other changes include the maximum-to-minimum values of the pulsating epicycle's radius. In the traditional system, Mercury's *Manda* epicycle radius varies from 1/12 to 1/12.86 and Venus's from 1/30 to 1/32.73. In Nīlakaṇṭha's model the corresponding values are 1/6 for Mercury and 1/14 to 1/28.3 for Venus.

But perhaps the most striking change in Nīlakaṇṭha's model is in the number of steps required for determination of true longitude. The traditional system has a 4-step calculation process for both inner and outer planets. In

Nīlakaṇṭha's model the outer planets have a 4-step calculation while the inner ones have a 2-step calculation. This change has major implications for the inner planets. It means that the first step (in the 2-step process) must produce the true heliocentric longitude of the planet, which further implies that the *Manda* assumed for the inner planets must be their aphelion. However Nīlakaṇṭha's assumed values for the *Manda*, especially for Venus, do not match the aphelion. Clearly the picture is incomplete and there are undoubtedly some issues to iron out here.

Presentation-wise, a minor shortcoming in the book is that each chapter seems to begin rather abruptly without an introduction of any sort. The typical reader will surely expect to have a gist of what's forthcoming in the chapter and how it relates to material already covered. The authors, for some reason, have chosen to lump together all chapter summaries in the *Introduction* chapter. These summaries would have been better placed at the beginning of each chapter. Another annoyance, especially for western readers and those unfamiliar with Sanskrit, may be the continued use of Sanskrit technical terms. Once a Sanskrit term has been translated into English, from that point onward only the English equivalent should have been used, except where the context requires the Sanskrit term specifically.

Figures, as mentioned, are plentiful throughout the book giving the reader a comfortable, visual feel for the concept being explained. Almost all of these figures are excellent except the odd one, like Fig. 2.7 for example, where the reader will have to labor a little to grasp the concepts being explained.

Perhaps the only major lacuna felt in the book is the lack of worked examples of Nīlakaṇṭha's model, which would have greatly enhanced the value of the book. However that omission will probably disappear soon as researchers begin to test out computationally the algorithms presented in the book and publish their findings.

Coming now to a contentious issue, the authors seem to have needlessly courted controversy by making some hasty assertions in the book. Researchers working on the traditional Indian planetary model will be taken aback by the authors' contention that the traditional model for the minor planets is 'wrong' and that Nīlakaṇṭha has 'corrected' and 'unified' the model. Nīlakaṇṭha has no doubt unified certain aspects of the system. But, as

mentioned earlier, in doing so he has also introduced some asymmetries, for e.g.:

1) Where there was only a 4-step process, now we have 4-step for outer planets and 2-step for inner.

2) Where there was only a pulsating epicycle for all, now we have pulsating for *Manda* and non-pulsating for *Śīgra* epicycles.

In lieu of this, it would be more correct to say that Nīlakaṇṭha's model is a 'variation'of the traditional model rather than a 'correction'.

But disregarding this minor controversy, overall, it is a useful and enjoyable book that adds to the widening spectrum of our knowledge of ancient Indian astronomy. The authors are to be congratulated for their painstaking and meticulous effort at deciphering the ancient verses and providing lucid explanations.

Apart from being a welcome addition to the sparse technical literature regarding the Kerala School, this volume will also prove beneficial to anyone interested in Indian astronomy. The novice will find it an able guide to help him overcome a steep learning curve while the expert will hone his understanding in several areas. It is hoped that many more such works will be brought out highlighting the ingenious works of the Kerala School of Astronomy and Mathematics.

In summary, besides being an outstanding reference to Nīlakaṇṭha's renowned work,the book is also a good resource for anyone interested in the minutiae of Indian astronomy. The chapter on *Gnomonic-Shadow* by itself is a good reason to have it in one's shelf. The serious researcher cannot afford to be without it.