Indian Journal of History of Science, 35(1), 2000, 77-86

BOOK REVIEWS

M. D. Pandit, *Līlavatī of Bhāskarācārya* (translated into English with Notes and Appendices), part I (*Parikarmāṣṭaka*), Pune, 1992, 100 pp. Rs. 40.

The University Grants Commission organised a meeting in August 1989 in the University of Poona to review for introducing scientific and technical literature in Sanskrit syllabi at the M.A. level of the universities. The Board of Studies in Sanskrit, Pali and Ardhamagadhi of the Poona University accepted the suggestion of this Committee and recommended a portion of the well known text of *Līlāvatī* of Bhāskarācārya (b. 1114 AD) in its revised syllabus to acquaint the students with glimpses and richness of ancient Indian mathematics. The responsibility for preparing a text book on *Līlāvatī* within a short period of time was given to Professor M. D. Pandit of the same Department, a competent exponent of Veda, Vedānta, Vyākaraṇa, Gaṇita, Astronomy, Astrology as well as of Science of Linguistics and Comparative Philology. The book under review is the outcome of this venture.

The book contains a preface, analysis of the first thirty verses of *Līlāvatī* (total verses 261) in nine sections—*maṅgalācaraṇa, paribhāṣā* and eight fundamental operations (addition, subtraction, multiplication, division, square, square-root, cube and cube-root) besides six appendices. These appendices deal with glossary of technical terms, modern symbols for mathematical operations, unstated techniques involved, word numbers, tradition of quoting first sentence referring to earlier texts, English equivalents for place-values of the place-names given by Bhāskarācārya and a selective bibliography.

The preface quotes the well known inscription discovered by Bhau Daji to show Bhāskarācārya's family tree left by his grandson Caṅgadeva, who was a famous astrologer in the court of Siṅghana of Devagiri in1210-1237 AD. There is no information whether Bhāskarācārya was associated with any king. He however has himself stated that he is the son of Maheśvara and resided in a place called Vijjalaviḍa near Sahya mountains. Vijjalaviḍa has been identified with

modern Patan on the boarder of Nasik and Aurangabad by Shankar Balkrishna Dikshit though it has not been accepted by N. H. Phadke and others. The preface also refers to Bhāskārācarya' works on astronomy (*Siddhānta Śiromaṇi)*, arithmetic (*Līlāvatī*), algebra (*Bījaganita*) besides others, place of *Līlāvatī* in mathematics, different legends connected with the name of *Līlāvatī etc.* Prof. N. N. Kolhapure, Chairman of the Board of Studies in Sanskrit, Pune University, in his preface to the volume believes in the story that *Bhāskarācārya* wrote it for his daughter *Līlā* who was his pupil, while Professor Pandit adds with more weightage, "It is from the initial word *līlā* in the stanza that Bhāskāracārya derived an adjectival form *līlāvat* with the *taddhita* suffix-*vat*, and since arithmetic was called *pāṭīganita* or simply *pāṭī*, the derivative *līlāvat* was transformed into its feminine as *līlāvatī*. And it is with this name *līlāvatī* that Bhāskāracārya himself designated his work." The remaining nine sections of the book supply original verses from *Līlāvatī* with *pada-pātha*, construction, translation and notes to make the *sūtras* more simpler and meaningful to the students. The fundamental operations are explained with examples. To make the operations meaningful the importance of place-value with only ten symbols in Indian tradition is explained with the details of operational steps of placing of numbers in each step. For addition and subtraction, the *krama* (right to left) *utkrama* (left to right) order of placing the scale and operational steps are correctly explained with examples. The methods of multiplication is likewise explained with the help of ranking of numbers in the scale (*sthānavibhāga)* and splitting of both multiplier (*guṇya*) and multiplicand (*guṇaka*) with connotation of technical terms like *ādi* (first term from the right), *upāntim* (middle term) and *antya* (last term from right). So is explained the method of division with terms dividend (*bhājya)*, divisor (*bhājaka*) and quotient (*labdhi* or *phala*) including the rules of divisibility by 2, 3, 5.

For square, square-root, cube and cube-root, the pattern of algebraic methods viz. $a^2 = a \times a$, $(a + b)^2 = a^2 + 2ab + b^2$, $a^3 = a \times a \times a$, $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$ etc used before by Āryabhaṭa I, and others are used.

The book is unique in many ways. Prof. Pandit has tried to establish the standing of Bhāskāracārya as a scholar of astronomy and mathematics by adducing his works and geneology, time of the text, the ambiguity about the name of the text. He has tried to explain each and every Sanskrit verse of the text with *pada pāṭha*,

construction, English translation, notes and examples in such a manner that even his students with limited knowledge of Sanskrit and high school standard in mathematics will be able to understand the intricacies thoroughly. Prof. Pandit has also tried his best to be faithful in his explanation of the text and has handled the examples without any distortion. His reference from inscriptional and other sources shows his sincerity in clearing doubts from his students's mind. He has explained the background materials of the origin and importance of place value in mathematical system and simplification of the system by the Indian mathematicians with base of ten numerals and the methodology followed by Bhāskarācārya in explaining the fundamental operations. His appendices containing technical terms with English equivalents, list of word numbers, explanation of certain unexplained mental techniques and others have made the book useful and distinct in nature.

However the book contains several errors and misrepresentation of facts. On p. 19 the statement that Bhāskarācārya's *Līlāvatī* is the first known text book on mathematics is not correct. Before Bhāskarācārya's *Līlāvatī*, Āryabhaṭa I's *Gaṇita* and *Daśagītikā* sections of *Āryabhaṭīya*, Brahmagupta's *Gaṇita* and *Kuṭṭaka sections of the Brāhmasphuṭasiddhānta, Bakhshālī Mathematics*, Mahāvīra's *Gaṇitasārasaṃgraha*, Śrīdhara's *Pāṭīgaṇita* were regularly taught and written in a style which is meant for the students following *gurusiṣyaparamparā* (teacher-student) tradition. Obviously the justification given in p. 20 "Why mathematics did not develop as an independent pure science" is not meaningful. On p. 51 the step 2 under section 4.1 is misplaced and is to be set aright by shifting one place to the left. Spelling mistakes are too many to be mentioned here. We hope that the book with these corrections in future edition will be an ideal text book for student with elementary knowledge of Sanskrit and Mathematics.

A.K. Bag

Gyula Wojtilla, *History of Kṛṣiśāstra*, Acta Universitatis de Attila Jozsef Nominatae; Acta Antiqua et Archaeologica, Supplementum IX, Szeged, Hungary, 1999, 35 pp., including Appendices, Bibliography and Abbreviations.

This small booklet contains a mine of textual information about our ancient past in the field of agriculture available through extant sources. Prior to medieval times, a very meagre amount of literary evidences is available pertaining to the

agricultural science. Nonetheless, some evidences available in the ancient texts such as *Agnipurāṇa, Arthaśāstra, Bṛhatsaṃhitā* make one wonder whether these texts are earlier than the oldest extant *kṛṣiśastra*!

This booklet brings forth a very clear definition to the *kṛṣiśāstra* which more often than not makes one believe to be associated only with farming and allied activities. Professor Wojtilla, a Hungarian Indologist who has made significant contributions to the study of history of agriculture in India, has shown the differences in the meaning of seemingly alike sciences such as *kṛṣiśāstra, kṛṣitantra, kṛṣipurāṇa, phalaveda, vṛksāyurveda* etc. According to the author, there is a remarkable coincidence between the appearance of *krṣiśastra* as a literary genre and the literary form both in Indo-Aryan and Dravidian languages and the extension of cultivated territories in which agricultural experience met the theoretical knowledge of brahmaṇas who played the role of cultural missionaries at places and times. Wojtilla further puts that their role became much visible in the coining of Sanskritized terms of agriculture, supplying theoretical knowledge of astronomy, botany, economy and in codifying popular wisdom deposited, for example in the collection of sayings in vernaculars. However, apart from mainly dealing with the theoretical and practical knowledge concerning agriculture, the ancient *kṛṣiśāstras* were a storehouse, full of topics related also to animal husbandry,veterinary science, arboriculture, horticulture and often passages related to *dharmaśāstra* or *arthaśāstras*.The author has further mentioned about various extant individual *kṛṣiśāstra* literature available in different Indian languages such as 9 in Sanskrit (*Kāśyapīyakṛṣiśūkti, Kṛṣiparāśara, Kṛṣiviṣayaka, Kṛṣiśāsana, Kṛṣisamayanirṇaya, Kedārakalpa, Kṣetratattva, Kṣetraprakāsa, Sasyānanda*); 3 each in Bengali (*Cāṣāpālā, Khanār bocan* and *Dāker bocan);* Malayalam (*Kṛṣigītā, Kṛṣicakrañnal and Kṛṣipāṭṭu) and Telugu (Sasyānandamu* and its two other variations); 2 in Tamil (*Erelupatu* and *Tirukkaivakkam*); one each in Hindi, Gujarati, Marathi and Rajasthani (*Ghāgh aur Bhaḍḍari kī kahāvaten); Dāker bocan* in Assamese and Maithili and *Nuskha dar fann-i-falāḥat* in Persian. Moreover this booklet also makes mention of the independent chapters on *kṛṣi* in different important texts such as *Arthaśāstra, Bṛhatsaṃhitā, Raṭṭamata* or *Raṭṭasūtra, Lokopakāra* and *Viśvavallabha.*

An exhaustive bibliography at the end of this monograph makes it a significant, authentic and valuable guide for researchers in this area. Professor Wojtilla deserves a scholarly ovation for providing an in-depth knowledge of Indian Agricultural and allied Sciences.

A. N. Thakur

Burkhard Stautz, *Untersuchungen von mathematisch-astronomischen Darstellungen auf mittelalterlichen Astrolabien islamischer und europäischer Herkunft,* [Investigations into the mathematical and astronomical representations on medieval astrolabes of Islamic and European origin], Verlag für Geschichte der Naturwissenschaften und der Technik, Bassum, 1997, 287 pp., 128 plates, ISBN 3-928186-29-9, DM 95.

It is axiomatic that scientific instruments form an important genre of source materials for the history of science and technology. There have been sporadic efforts, in the late nineteenth and early twentieth centuries, to study some scientific instruments as also the texts that deal with them. In 1964, Professor Derek Price mooted the idea of cataloguing the astrolabes scattered all over the world. Nine years later, in 1973, he brought out, together with Sharon Gibbs and Janice Henderson, *A Computerized Checklist of Astrolabes* from Yale University, New Haven. Since then various attempts are being made to update the *Checklist* and to compile national inventories of scientific instruments. The most ambitious and comprehensive of such surveys is the *Catalogue of Medieval Astronomical Instruments,* which is under preparation at the Institute of History of Science of the University of Frankfurt by Professor David King, foremost authority on Islamic scientific instruments.

The book under review is the doctoral thesis of Burkhard Stautz, a worthy pupil of Professor King. In this work, Stautz seeks to study and analyse, by means of the modern computer, the mathematical and astronomical data contained in some 190 Islamic and European astrolabes, which were produced during the period between the tenth and sixteenth centuries.

There are five chapters in this book. The first chapter (pp. 15-35) lays down the methodological framework of the investigations. The mathematical and astronomical data are engraved on the astrolabe not as numbers but in the form of

what are called "nomogramms," i.e., lines and curves which are laid out according to certain trigonometric principles. In an astrolabe these nomogramms occur on the star maps, on tympans and on the back of the astrolabe. To take the case of the star maps: these circular open work discs display by means of projecting bits (of diverse shapes and sizes) the positions of some prominent stars, situated on either side of the ecliptic. The positions are marked by stereographically projecting the ecliptic coordinates (i.e. longitudes and latitudes) of the stars on to the two-dimensional disc of the astrolabe. Where does the astrolabe maker obtain the co-ordinates from? He takes them from star catalogues or manuals on the astrolabe and updates them by adding to the longitudes precession up to his time. The selection of the stars as well as the rate at which precession is added yield valuable clues to the tradition followed by the astrolabe maker and may point to the linkages between the tradition of instrument making on the one hand and the textual tradition of star catalogues and astrolabe manuals on the other. An analysis of the nomogramms thus enables us to "situate" the astrolabe within the scientific tradition of the period and place.

For analysing the nomogramms on the star maps, Stautz devised an effective method. Instead of reconverting the nomogramms into longitude and latitudes (expressed as numbers) and comparing these with coordinates computed afresh to see the rate of error in the astrolabe, Stautz decided to compare nomogramms on the star maps directly with computer-generated star maps. The advantages of this method are obvious. Not only does this allow a comparison of the positions of all the stars in one glance; it also allows the creation of multiple sets of star positions, using various parameters such as different rates of precession, in order to see which set matches with the nomogramms on the astrolabe. Thus for each astrolabe to be studied, Stautz created a star map on the computer, printed it on a transparent folio, superimposed this folio on the star map of the astrolabe, and studied the pattern of divergence. The book reproduces over one hundred composite pictures of the original star maps on which the computer-generated versions are superimposed. From these, the reader can judge himself how effective this method is.

The second chapter (pp. 37-43) deals with the earliest form and design of the astrolabe star map, as it may have come down from the Hellenistic tradition to the

Islamic world, on the basis of two astrolabes: a Byzantine astrolabe dated 1062 AD, which is attributed to Sergius the Persian and now preserved in Brescia in Italy, and an undated and unsigned astrolabe from Baghdad.

The third chapter (pp. 45-79) is devoted to Islamic astrolabes. Most of the early Islamic astrolabes carry dates of manufacture and thus can be classified both according to chronology and provenance. Stautz arranged these astrolabes into seven chronological and spatial groups and studied their development from the first quarter of the tenth century to the fifteenth century. The comparison of the nomogramms shows that a great majority of these astrolabes are scientifically very accurate. Linkages are also found between the astrolabes and star catalogues. The earliest astrolabes were produced about 925 AD. The analysis of their star maps brings out the linkages between these astrolabes and the star catalogue given in the *Zīj al-Mumtaḥan* compiled by Yaḥyā ibn Abī Manṣūr on the basis of his observations made about the year 829 AD and also the star table used by al-Farghānī (fl. 850) in his work of the astrolabe. The analysis also shows the gradual development of the design of the star map over the centuries and the regional divergences between eastern and western Islam.

It is well known that the science of the astrolabe was transmitted from the Islamic world to Europe. This transmission and the texts and astrolabes it generated in Europe are dealt with in the fourth chapter (pp. 81-110). However, the nearly 130 early European astrolabes were not very accurate. Stautz's analysis reveals that the astrolabes makers took the star coordinates from various catalogues but did not update them before incorporating them into their astrolabes. But things improved after 1450, with noted astronomers like Georg Peurbach (1423-1461) and Regiomontanus (1436-1476) taking active interest in the astrolabe. Astrolabes belonging to their tradition, produced in the region of southern Germany, are discussed in the fifth chapter (pp. 111-126). This is followed by a list of 190 astrolabes used in this study together with their technical details and literature where they were discussed (pp. 127-140), bibliography (pp. 141-152), index (pp. 153-157) and 128 diagrams and plates (pp. 161-287).

This is truly an impressive and path-breaking study and one of the most important books to appear on the astrolabe in recent years.

S. R. Sarma

Ileana Chinnici, *La Carte du Ciel: Correspondance inédite conservé dans les archives de l'Observatoire de Paris*, [The Carte du Ciel: Unpublished Correspondence preserved in the Archives of the Paris Observatory], Observatoire de Paris, Paris & Osservatorio Astronomico di Palermo G. S. Vaiana, Palermo, 1999, xviii + 475 pp., 56 plates, ISBN 2-901057-40-3. Price not mentioned.

Apart from observing the motion of the planets and calendar making, charting the heavens, i.e. preparing star maps, has been a favourite pastime of astronomers of all ages and civilisations. For long such attempts were based on naked eye observations, but a revolutionary break-through came from the developments in Europe such as the invention of the refracting/reflecting telescopes with accessories for the measurement of stellar co-ordinates, electric photometry for estimating the magnitude of stars, and especially photography in 1838 by the Frenchman J. L. M. Daguerres and J. N. Niepces. The pioneers in astro-photography were two astronomers, H. Draper and L. M. Rutherford. The former photographed the moon already in 1839 and the latter perfected the technique by 1885. These advanced techniques for star mapping first culminated in the publication of *Bonner Durchmusterung* by the German astronomer Friedrich Argelander (1799-1875). This comprehensive star catalogue comprised 15 volumes which list the data for 150,00 stars. With the advent of photometry, two colleagues of Argelander, Schönfeld and Krüger estimated during 1852-1868 at the Bonn Observatory the brightness of 314,189 stars upto the magnitude of 9.5 and declination of -2°.

Therefore, it was resolved in the Congres astrophotographique held at the Paris Observatory in April 1887 that a comprehensive project for the photographic charting of the heavens be undertaken with the cooperation of several observatories located all around the world and with the Paris Observatory as the nodal centre. The project was commenced afterwards under the name *La Carte du Ciel*. With eighteen observatories from twelve countries participating, this was truly the first international scientific project and it continued up to 1964. The project was divided into two sections: (1) Chart of the Heavens, and (ii) the Astrographic Catalogue. The Chart never took off. The Catalogue was completed in 1964, full seventy years later than expected. Each observatory published on an average ten volumes of the Catalogue, for a total of more than 160 volumes.

As Johannes Anderson, the General Secretary of the International Astronomical Union, observes in the Foreword to the volume under review, "... although scientific

and technical developments made the original chart project itself obsolete, the *Carte du Ciel* catalogue stands out as a monument to what dedicated scientists can achieve through international collaboration despite all difficulties."

The voluminous correspondence between the various observatories with the Paris Observatory is preserved in the archives of the Paris Observatory. With a great sense of devotion and painstaking research, Dr. Ileana Chinnici of Palermo Observatory edited this correspondence and put it together in this present volume, which was sponsored by the International Astronomical Union and published jointly by the Observatories of Paris and Palermo.

Chinnici was entrusted with the project of preparing a scientific biography of the eminent Italian astronomer Pietro Tacchini (1830-1905), who actively promoted the participation of Osservatorio Astrofisico di Catania in the *Carte du Ciel* project and who made valuable observations during his tenure at the Palermo Observatory. While researching on Tacchini's scientific output and his large corpus of correspondence in the archives of the Paris Observatory, Chinnici had the idea of first publishing the correspondence connected with the *Carte du Ciel* project because this "project is a paradigm of an extremely large project that has motivated and kept busy many astronomers for many years, that has suffered much from its dimensions, while, at the same time, producing impressive results."

The opening pages offer the plan of the work, a description of the archival collections, the criteria for the selection of documents and the method of transcription of the correspondence (pp. xii-xviii). The book is divided into four parts. Part I (pp. 3-10) contains a brief historical introduction, describing how the *Carte du Ciel* project gradually developed from the idea of a photographic chart of the entire sky, first put forward by Warren de la Rue at the Observatory of Kew, Great Britain, in 1857, and later on elaborated in 1882 by Edward C. Pickering of the Harvard Observatory and by David Gill of the Cape of Good Hope Observatory. Part II (pp. 12-43) provides (in English and French) 'Instructions to the Readers' and a list of the senders of the *Carte du Ciel* correspondence, complete with the dates of their birth and death, besides the place and date of the particular letters.

Part III (pp. 46-448) constitutes the main body of the work, containing as it does the text of 732 letters in the language in which they were written. These are arranged observatory-wise. These letters and documents trace the onset and execution of the *Carte du Ciel* and supply useful elements to evaluate the contribution of the participant observatories.

Part IV (pp. 451-466) focuses on the special contribution of the French and Italian observatories in this project. The documentary value of this volume is enriched by 56 plates containing the photographs of the participating observatories, their equipment and also of some of the leading astronomers together with facsimile reproductions of some of their letters.

The readers of this Journal would be interested to know that the Nizamiah Observatory of Hyderabad also took part in this project. Two letters respectively from the Nizam's prime minister and from Chatwood of the observatory allude to this participation (p. 240). There is also a photograph of this observatory (pl. 32). As a matter of fact, this was the only observatory from Asia which took part in this international project. As Dr. Chinnici informs me in a personal communication, the Hyderabad Observatory replaced the Santiago Observatory in 1909 and its work was well executed. Most of the correspondence concerning the Hyderabad Observatory appears to have been kept in English archives. There are only two letters in the Paris Observatory. The participation of the Hyderabad Observatory in the project was due to the intervention of H.H. Turner (see his letter of November 8th, 1908, on p. 296). The Hyderabad Observatory published twelve volumes of the Astrographic Catalogue, covering the sky zone –17 to –23 degrees. In 1928, the Hyderabad Observatory was asked by the Commission 23 of IAU to cover partially also a sky zone previously assigned to the Potsdam Observatory, and the Hyderabad Observatory carried out the work for the zone 39 to 36 degrees. Its help was therefore very important for the completion of the Astrographic Catalogue. By this time both China and Japan possessed well equipped observatories and were in the main stream of modern observational astronomy. Therefore, it is rather intriguing why no Japanese or Chinese observatory took part in this venture. The documents collected by Chinnici do not throw any light on this question.

Be that as it may, this meticulously edited and finely produced volume of correspondence is a fitting tribute to the great scientific endeavour. This volume is, on the one hand, a working tool for historians of observational astronomy dealing with the events of the nineteenth and twentieth centuries and, on the other, a book of great intrinsic value by making tangible the bold vision underlying the great scientific enterprise of the *La Carte du Ciel.*

S. M. R. Ansari