INDIAN LITERATURE ON MATHEMATICS DURING 1400—1800 A.D.

A. K. Bag

Indian National Science Academy

New Delhi 110002

(Received 30 August 1978)

The available Indian literature on mathematics during 1400-1800 A.D. can be broadly classified into two main categories. In the first category belong the Sanskrit works, or the works written in scripts of the regional Indian languages. Though the scripts are different, the language of these scripts is mainly Sanskrit and bears Indian tradition both in content and character. The major portion of these works are commentaries on the works of Sūrya Siddhānta, Āryabhaṭīya, Lilāvati, Bijaganita, Siddhānta Siromani, and some other well-known works of the ancient period, and contribute little to the knowledge of mathematics. The commentators of this period were perhaps content with the preservation and transmission of knowledge from one generation to the other. Their studies gave some impetus to the studies of the scholars like Mādhava, Parameśvara, Nīlaṅgha, Śaṅkara, Jyeṣṭhadeva, Acyuta Prāraṇṭi, etc., for about 500 years starting from fourteenth century A.D. These scholars made some break-through by introducing the idea of series in calculating the value of π, sine-table, discovery of the sine and cosine series and made many other innovations. The second category of mathematical literature constitute the Persian and Arabic works developed mostly under the patronage of the Mughal rulers. These were mainly written for readers of Persian who knew no other language and had no access in standard Sanskrit, Persian and Arabic mathematical works. Many standard mathematical works were brought here from outside India. Some scholars tried to translate or write commentaries on the available works without trying to correlate with the available Indian knowledge. A few scholars like Muniśvara, Kamalakara, Jagannāth Paṇḍit tried to make a synthesis of the available knowledge but their contribution appears to be negligibly small. The real contribution lies in the efforts of Raja Jai Singh who used the observatories at Delhi, Jaipur, Mathura, Banaras and Ujjain to prepare accurate astronomical tables. In the paper, an attempt has been made to make analysis of these two categories of mathematical literature in the period.

The Indian literature on Mathematics during the period 1400—1800 A.D., as available now in different oriental libraries, can be broadly classified into two different categories. To the first category belong the sanskrit works, or the works written in scripts of the regional Indian languages. Though the scripts are different, the

*Paper presented at National Seminar on “Technology & Science in India during 1400-1800 AD” held at Indian National Science Academy, New Delhi; April 20-21 1978.
language of these manuscripts is mostly Sanskrit and bears Indian tradition both in content and in character. The second category of mathematical literature consists of Persian and Arabic works produced mostly under the patronage of the Mughal rulers. An attempt has been made to make an analysis separately of these two categories of mathematical literature.

1. **Works in Sanskrit Literature**

Thousands of works were written in the period. A few of the prominent works by well-known scholars have been summerized to have an idea of the type and trend of mathematical literature.¹

Gaṅgādhara (c. 1400), the son of Govardhana and grandson of Divākara, was an inhabitant of Jambusāgaranagar. His commentary Gaṇitāṅkumāra is a commentary on the Lilāvati of Bhāskarācārya. It appears almost verbatim of the original work.

Mādhava (c. 1400) of Saṅgamagrama near Cochin was a well-known scholar in astronomy and mathematics.² He is referred to as golavid by his student Parameśvara and Nilakaṇṭha. His Venivṛtha gives a method for the computation of the moon and Sphutacandrāṇi accounts for calculation of true moon. He is also known to have written Lagnaprabhāṣa and Mahābhāṣyana prakaraṇa. Apart from these works, a number of these verses of Mādhava are quoted by later astronomers like Nilakaṇṭha, Somayāji, Nārāyaṇa (commentator of the Lilāvati), Śaṅkara (commentator of Tantra Saṅgraha), etc.

Parameśvara (c. 1430), a resident of South Malabar in Kerala, was the student of Rudra, Nārāyaṇa and Mādhava. He is well-known for his lucid commentaries and knowledge in mathematics and astronomy. Among his works, the Bhāṣadīpikā (commentary on Āryabhaṭīya of Āryabhaṭa-I), Karmadīpikā (comm. on the Mahābhāskarīya of Bhāskara I), Parameśvari (commentary on the Laghubhāskarīya of Bhāskara-I), Siddhāntadīpikā (comm. on the Mahābhāskarīyabhaṣya of Govindasvāmi), Vivaraṇa (commentary on the Sūryasiddhānta and Lilāvati), Dṛṣṭgaṇita (dyk system), Goladīpikā (spherical geometry and astronomy), Grahaṇamanaḍana (computation of eclipses), Grahaṇavyākhyādīpikā (on the rational of the theory of eclipses), Vākyakaraṇa (on the methods of the derivation of the several astronomical tables) besides others are well-known. Parameśvara was a practical astronomer and realised the limitations of previous scholars in the calculation of eclipses and devised correction for finding mean position of the sun, moon, apsis, node, etc.

Nilakaṇṭha Somasutvan (c. 1443—1543) was a student of Parameśvara and is well-known for his contribution to mathematics and astronomy. He is the author of Āryabhaṭīyabhāṣya, Tantra Saṅgraha (tantra collection), Grahaṇanirṇaya (computation of lunar and solar eclipses), Golasāra (quintessence of spherical astro-
nomy). Siddhāntadarpaṇa (mirror of the laws of astronomy), Candracchāyāgaṇita (computation concerning moon’s shadow), Candracchāyāgaṇitāṭikā. He has quoted profusely from the Vedāṅgajyautiṣa, Āryabhaṭiya, Pāñcasiddhāntikā, Brhajītaka, Brhatsaṅhitā, Sūryasiddhānta, Siddhāntaśekhara, Laghumānaṇa, etc. He is mainly an astronomer and well-known for methods of determining corrections, rational of eclipse correction, procedures for observation of planets with instruments and for their computation using the data obtained from the observation.

Yallaya (1482), son of Śridharaścārya, was the pupil of Sūrya. He is well-known for his works Āryabhaṭiya, Vyākhyāna, (commentary on the Āryabhaṭiya of Āryabhaṭa), Jyotiśadarpaṇa, Kalpavali (commentary on the Sūryasiddhānta), Laghumānaṇa Kalpalata (a commentary on the Laghumānaṇa of Mañjulācarīya), and Gaṇitasaṅgraha (a treatise on arithmetic).

Śaṅkara Vāriar (c. 1500-1560), the brother and student of Nilakantha is the author of Laghuvaṃṣṭi, a scholarly commentary on the Tantrasaṅgraha. Śaṅkara seems to have well-versed in astronomy and in following his brother Nilakantha. It is expressed by Nilakantha in some of the passages that he had complete faith in his brother in studies of mathematics and astronomy. He wrote another work, Kriyākramakari, an elaborate commentary on the Lilāvatī of Bhāskara II giving rational and proof of the theorems and formulae. The work is more or less identical with the Karmapradipaka of Nārāyaṇa, only difference is that Śaṅkara's work is more elaborate.

Jyeṣṭhadeva (c. 1500—1600) is a well-known Kerala scholar on mathematics and astronomy. His Yuktibhāṣā (rational explanation) was written to provide the basic equipment needed for the study of computation of planetary movements as depicted in the Tantrasaṅgraha. The work is divided into two parts, the first comprising of arithmetic, geometry and algebra and the second exclusively devoted to the astronomy, spherical trigonometry and allied subjects. It gives the rational or derivation of all theorems and formulae then in use among the astronomers.

Cakradhara (c. 1500), son of Varuṇa, wrote his Yantracintāmaṇi, a treatise on astronomical instruments in four chapters, viz. Yantraprakaraṇasūdhana, Tripaśnādhikaṇḍa, Grahāṇayanādhikaṇḍa and Prakīrṇādhīya. He also produced a commentary on his own Yantracintāmaṇi.

Jñānarāja (c. 1503) was the son of Nāganātha of Pārthapura. He is well-known for his Siddhānta-sundara dealing with astronomy. The Sphuṭādhīya chapter contains sine table. His Sundarasiddhāntabija is another work on algebra which was written as a sequel to Bhāskara II's Bijaganita.

Gaṇeśa Daivajña (b. 1507), the son of Keśava Daivajña of Nandigrāma (Nandod, Gujrat), was an influential teacher and the author of not less than seven
works, viz. Bhātthithecintāmaṇī (treatise on the preparation of lunar calendar), Laghucintāmaṇī (abridgement of bigger work), Buddhivilāsinī (commentary on the Lilāvati of Bhāskarācārya), Drhuvaabhramaṇa Yantra vyākhyā (commentary on the Drhubabhramaṇa Yantra of Padmanābha), Grahalāghava (simplification of Planetary computation), Pratodayayantra (special class of astronomical instruments), Cābuka Yantra, Sudhiraṅjana Yantra and Siddhāntasiromaṇi vyākhyā (a commentary on the Siddhānta Śiromaṇi of Bhāskara II).

Sūryadāsa (c. 1541), son of Jñānarāja, wrote two commentaries, viz. Gaṇitāmṛtakūpika, a commentary on the Lilāvati of Bhāskara II, and Sūryaprakāśa-Bijavyākhyā, a commentary on the Bijaganita of Bhāskara II.

Raṅganātha (c. 1578) son of Ballāla and father of Munīśvara wrote a commentary on the Sūryasiddhānta. The commentary is well-known for its style and lucidity.

Dinakara (c. 1578) wrote three works. His Candrārkī deals with true place of the sun and moon in astronomy in 33 verses. His Khetasiddha describes methods for finding the true place of the planets. He also wrote commentary to his own Candrārkī.

Acyuta Piṣāraṭi (c. 1580), a non-Brahmin astronomer, mathematician of Kerala, was a student of Jyeṣṭadeva. He, for the first time in Indian astronomy, incorporated the correction in the Sphuṭtanirnaya and explained its rational elaborately in his work, Rāśigolasphuṭaniti (ed. by K. V. Sarma, Adyar Library, Madras, 1955). The correction was first introduced in Western astronomy by Tycho Brahe at about the same time. His Karaṇottama (ed. by Raghavan Pillai, TSS 213, Trivendrum, 1964) deals with astronomical computation. He wrote commentaries on Sūryasiddhānta, Veṇāroha of Mādhava and on his own Sphuṭtanirnaya and Karaṇottama.

Viṣvaṅgītha Daivajña (1580) son of Divākara Daivajña was a powerful teacher and commentator. He comes of an astronomer family which traces his ancestry back through a long line of astronomers in Maharashtra. He wrote as many as ten commentaries besides other works on almanacs. The works are Sūryasiddhāntadāharaṇa (commentary on the Sūryasiddhānta), Grahakautukodāharaṇa, (commentary on the Grahakautuka of Keśava Daivajña), Grahalāghavodāharaṇa (commentary on the Grahalāghava of Gaṇeśa Daivajña), Karaṇakutukhalodāharaṇa (commentary on the Karaṇakutukhalal of Bhāskara II), Mākaranodāharaṇa (commentary on the Tithipatra of Makaranda), Rāmavindodāharaṇa (commentary on the Rāmavinda of Rāma Daivajña), Śiromanyudāharaṇa (commentary on the Siddhāntasiromaṇi of Bhāskara II), Somasiddhāntaṭīkā, Vaśiṣṭhasiddhāntaṭīkā and others.

Nṛṣimha Daivajña (1586), son of Kṛṣṇa Daivajña and grandson of Divākara Daivajña Golagrāma (Maharashtra), wrote these commentaries, viz, Vāsanā Vārtika,
(commentary on the Siddhánta-śiromani of Bhāskara II), Saurabhāṣya (commentary on the Sūryasidhānta) and Tithicintāmaniṭikā (commentary on the Tithicintāmani of Gaṇeṣa Daivajña).

Nilakaṇṭha Jyotirvid (c. 1587), son of Ananta, was the Chief Paṇḍit of the Court of Akbar (1556-1605). He wrote Grahakautuka, Grahalāghavatikā, Makarandavivṛti (commentary on the Tithipatra of Makaranda), Saranikaṅṭhaka, Subodhinīṭikā (commentary on the Jaiminiyaśatra), Tithiratnāvalī.

Dhunḍirāja (1590) son of Nṛsiṁha was the inhabitant of Parthapura. He wrote as many as four works, viz. Ayanatattva, Grahamani (short astronomical treatise), Makarandodāharaṇa (commentary on the Tithipatra of Makaranda) and Paṅcāṅgaphala (on calendar).

Gaṅgādhara (1590), son of Nārāyaṇa, flourished in late half of the sixteenth century wrote Manoramā, a commentary on the Grahalāghava of Gaṇeṣa Daivajña.

The Karana-paddhatiṭa (1596) is an important astronomical work in ten chapters written by anonymous Kerala Brahmin family of Śivapura. The text is edited in Trivandrum Sanskrit series no. 126. Apart from usual elements and formulae characteristics of Hindu astronomy, the work gives the values of pi, sine, co-sine and tan series. This also used the idea of indeterminate equations to calculate māhāhāra and mahāguna required in connection with the calculation of the mean motions of planets.

Κρσν (c. 1600) was the son of Vallāla of Dadhigrāma (Vidarbh). He belonged to a prominent family of jyautiṣa, patronised by the King of Vidarbha. The family moved from Vidarbha to Benaras in the sixteenth century. He was the student of Viṣṇu who was the pupil of Nṛsiṁha, the nephew of Gaṇeṣa of Nandigrāma and was patronised by Jahangir (1605-1627) according to his younger brother Raṅganātha. He wrote three works, viz. Bījāṅkura (commentary on the Bijagaṇita of Bhāskara II), a commentary on the Jātakapaddhati of Śripati, and a commentary on the Līlāvati of Bhāskara II.

Divākara Daivajña (1603), son of Nṛsiṁha Daivajña, was the resident of Golagrāma (Maharashtra). He wrote Makarandavivarana (commentary on the Tithipatra of Makaranda), Pātasārīṇiṭikā (a commentary on the Pātasārīṇi of Gaṇeṣa Daivajña), Rāmavinoda prakāśapaddhati, and Tattvacintāmani.

Muniśvara (b. 1603), son of Raṅganātha and a cousin of Nārāyaṇa, was the main astronomer in the court of Shahjahān (1628-59). He wrote Marići, a commentary on the Siddhānta-śiromani of Bhāskara II, Nisṛṣṭārthaduti, a commentary on the Līlāvati of Bhāskara II, Pāṭisāra, a work on mathematics and geometry, Siddhānta-sārvasaṃkhyauma, an astronomical work and his own commentaries on it. He had a controversy with Kamalākara and tried to refute some of the latter's contribution.
Rāma Daivajña (1615), son of Madhusūdana was the resident of Parthapura. He wrote a commentary entitled Yantracintāmaṇi (commentary on the Yantracintāmaṇi of Cakradhara).

Kamalākara (c. 1616-1700), son of Nṛsiṃha Daivajña, was the descendent of Viśvanātha family of Golagrāma. He was born in Benaras. His brothers, Divākara and Raṅganātha, were also noted astronomers in Benaras in mid-seventeenth century. He was the court astronomer of Jahangir (1605-1627). He composed his work Siddhāntatattvaviveka in 1658 A.D. He was a follower of Śūryasiddhānta and tried to refute some of the views of the Bhāskara II and Muniśvara. Though Siddhāntatattvaviveka is mainly a work on astronomy, he made contribution to trigonometry by giving several correct relations between chords and its corresponding arcs in his section of Spaṣṭādyāya. Some of the passages of the Siddhāntatattvaviveka are evidently copied from the Elements. Other instances of resemblance can also be identified with particular propositions of Elements. On the whole, there is absolutely no doubt that Kamalākara had knowledge of Euclid’s Elements. His other works are Grahaogolatattva, Grahaśaraṇi, Kairasyudāharana (commentary on the Lilāvati of Bhāskara II), Manoramā (commentary on the Grahalaghava of Gaṇeśa Daivajña), Sauravāsanā (commentary on the Śūryasiddhānta) and Śeṣavāsanā, a supplement to the author’s Siddhānta-Tattvaviveka. Kamalākara combined traditional Indian astronomy with elements of Aristotelian physics, Euclidean geometry and Ptolemaic astronomy as presented by Ulug Beg.

Malayendusūri (c. 1659) wrote a commentary on the Yantrarāja of Mahendrasuri (c. 1320). It is a guide to the preparation of an instrument by means of which the times of day and night may be accurately ascertained. The work in 5 chapters are Ghaṭanā, Gaṇita, Yantraracanā, Yantrasodhana, and Vicārāna. Malayendu Sūri wrote another work Yantrarājaracanā which is also useful in the preparation of Yantrarāja.

Jayasimha (died in 1667), the ablest General under emperor Aurangzeb (1659-1709), was also a great patron of learning. His descendent Sawai Jayasimha or Jayasimha II became the prince of Amber in Rajasthan and stabilised his Kingdom in 1708. The prince was greatly interested in mathematics particularly in astronomy. Paṇḍit Jagannātha, the versatile scholar in Sanskrit worked under his patronage, and within a short time mastered in Persian and Arabic languages. A table known as Dṛkpaṇasaraṇī was prepared under his order. The table was used for finding lunar days according to the motion of the planets determined by means of astronomical observations. Another work, Yantrarāja was also compiled by him which contains directions for preparation of universal sundial.

Paṇḍit Jagannātha (c. 1667-1750) flourished under the patronage of King Jayasimha (1693-1743) of Amber. He was a great scholar of Sanskrit and acquired great proficiency in Persian and Arabic. He translated Euclid’s Elements from the Arabic version Tahirir-u-Uqlidas by Nasir-ud-din at-ṭusi (1201) under the
name of Rekhaṇgaṇita. His other works are Samrāṭ Siddhānta, a Sanskrit version of Ptolemy’s Almagest and Siddhānta Sārvabhauma which contains partly Samrāṭ Siddhānta and partly Hindu astronomy.

Nayanasukhopadhyāya (c. 1730) is the author of Ukarākhyā-granthā, a treatise on spherical trigonometry. This was prepared from an Arabic translation of a Greek work of anonymous author. The Arabic translation was perhaps done by Qusta b. Luqa. Nayanasukha took the help of the Abid for its translation into Sanskrit. The manuscript copy is available in the Calcutta Sanskrit College.

2. TRADITION AND TREND OF MATHEMATICAL LITERATURE IN SANSKRIT

The present survey shows that the major portion of these works are commentaries on the works of Śrīyāsidhānta, Āryabhaṭīya, Lilāvati, Bijaganita, Siddhānta-siromani and some other well-known works of the ancient and medieval period. The other works contain some improved results in trigonometry and methods for finding the position of the sun and the moon, duration of eclipses, rational explanation and the corrections on them. These works have been mostly produced by six well-known families or traditional schools in Jambusāgaranagara, Dadhirāma (Vidarbha), Nandigrāma (Gujrat), Pārthapura (Pathari, Parbhani, District, Maharashtra), Golagrāma (Maharashtra) and followers of the traditional schools which are as follows:

(a) Jambusāgaranagara:
Divākara - Govardhana - Gaṅgadhara

(b) Dadhirāma (Vidarbha)
Rāma - Trimala + Gopirāja
Trimala - Vallāla
Vallāla - Rāma + Kṛṣṇa + Govinda + Raṅganātha + Mahādeva
Govinda - Nārāyaṇa
Raṅganātha - Muṇśvara.

(c) Nandigrāma (Gujrat)
Kamalakara Daivajña - Keśava - Gaṇesa
Keśava - Rāma - Nṛsimha.

(d) Pārthapura (Maharashtra)
Nāgananātha - Jñānārāja - Śrīyadāśa
Nṛsimha - Dhuṇḍirāja (1575)
Madhusūdana - Rāma Daivajña (c. 1615)

(e) Golagrāma (Maharashtra)
Divākara Daivajña - Viśnu + Kṛṣṇa (1500 C.) + Mallāri +
Keśava + Viśvanātha
Kṛṣṇa - Nṛsimha + Śiva
Nṛsimha + Divākara + Kamalakara + Gopinātha + Raṅganātha.
(f) Kerala

Mādhava—student, Parameśvara
Parameśvara—son Dāmodara
Dāmodara—Pupils, Nilakaṇṭha Somasutvan + Jyeṣṭhadeva
Jyeṣṭhadeva—Pupil, Acyuta Piṣāraṭi—Pupil, Nārāyaṇa Bhattachāri.

The works produced by these scholars reflect fully the Indian tradition of writing commentaries or explanations which at times appear verbatim of the original work, sometimes with some insight into the ancient material without any change in content and character. In the process some success has been achieved in algebra through the application of continued fraction, in trigonometry with the help of the series, in arithmetic through the use of symbols, pāṭi and dust.

For example, Mādhava used the idea of series for calculating the circumference of the circle to be 28, 27, 43, 33, 88, 233 (13 figures) for a radius of $9 \times 10^{11}$, which gives the value of $\pi$ ($= 3.14159265359$) correct to 11 places of decimals. $21600 \times 9 \times 10^{11}$

In radian measure the radius of the circle came out to be $282743388233$

=3438°44′48″. From this the 24 mahaśyās or sine or cosine table correct to 7 or 8 places of decimals were calculated by applying sine and cosine series by Mādhava much before Newton. Nilakaṇṭha gave the value of the circumference of the circle of diameter 113 to be 355 which gives the value of $\pi$ as 3.1415929 (correct to 6 places of decimals). Some synthesis of available astronomical knowledge was tried by Muniśvara, Kamalākara and Jayasiṃha, for they had some opportunity to be familiar with Persian or Arabic version of Greek materials but it appears that these scholars were unaware of the development of mathematics in the south. To what extent these scholars and some muslim scholars under the Mughal rules have been effective to draw materials from the Persian/Arabic literature can be seen from our survey of Indo-Persian Literature5.

3. Indo-Persian/Arabic Literature During The Period

‘Abd al-‘ Azīz ibn Shams prepared a Persian version Tarjumah-i Bārāḥī of the Brhat Samhitā of Varāhamihira for Firoz Shah Tuglaq (1351 - 1388 A. D.). Out of the 104 chapters (bābs) in the original, only eight were left out in the translation. He might have written another Persian work, Nujūm al-Hind wa Saḥ'at - i - uṣṭurlūb on Indian astronomy and construction of astrolabe. The date of compilation is not available.

Muṣliḥu’d - din al - lārī al - Anṣāri flourished during the reign of Humāyūn (1530 - 40). Later he joined the Court of Mirzā Shāh Husain Arghun (1556), the ruler of Sind. He wrote a commentary on ‘Alā’ud - din ‘Ali Qāshji’s Risālah dar Hai’ at entitled Sharḥ Risālah i Qāshji. The manuscript is available in the Bankipur Library and State Central Library, Hyderabad.
The Lilāvati gained a wide popularity in India and was held in esteem in the time of Akbar (1556 - 1605). It is under his order, Abul Faizi, his court poet, prepared a Persian translation Tarjamanah - i - Lilāvati in 1587 A. D. (A. H. 995 - 6). This is mentioned in Aīn - i - Akbarī.

Mullāchānd was also the court astronomer of Akbar. He wrote a work on astronomical table, Tashilāt. This is referred by Farīd - ud Din in Zij - u - Shāhja hāni and Jai Singh Sawā'ī in Zij - i - Muḥammad Shāhī.

‘Atā’ullāh Qārī (Qadiri?) flourished during the reign of Bahrān Niṣām Shāh, ruler of Aḥmadnagar (1591 - 1595). His Risālāt Ma’rifat i A’māl i Rub’imujayya - i Āṣaqqi dealing with sine quadrant. The manuscript is available in the State Central Library, Hyderabad and Azad Library, Aligarh.

A Persian translation of the Bijaganita entitled Tarjamanah i Bij was made in India in 1634 - 35 A. D. by ‘Atā’ullāh Rashīdī, son of Ustad Aḥmad Nādir, the builder of Taj. He was originally a resident of Lahore and had his education under his father and Makramat Khan, well-known for his knowledge in mathematics. This was dedicated to Shahjahan (1628 - 1659). The Persian version was translated into English by Edward Strachey in 1813 A. D. From the translation it appears that it is not a faithful translation of the Bijaganita but is a mixture of text, commentary and some interpolations. The same author wrote perhaps two other works, viz, Khasinatril A’dad dealing with arithmetic, algebra, and applied geometry. Some discussion is also available on some astronomical problem. The other work is Khulasah -i- Baz dealing with arithmetic, mensuration and algebra in verse form. The manuscript copies are available in Bankipur and British Museum.

Farīd’ud-dīn Mas’sūd, son of Ḥāfis Ibrāhim Munajjīm was the court astronomer of Shahjahan. He was considered as a great scholar in mathematics, astronomy, geometry, etc. He wrote perhaps two works, viz. Sirjūl Istikhrāi and Zij -i- Shāhjahān in 1629 A. D. The former deals with eras, calculations of dates and principles of computation of almanacs. The latter is on calendars and astronomical tables. The manuscripts of both the works are available in the State Central Library, Hyderabad.

Lutfu’lāh Muhandis, the brother of Atā’ullāh Rashidi (c. 1634) and the second son of Ustad Ahmad, was also well-known for his interest in mathematics and other sciences. His Muntakhab is a short versified translation of Baha’ud - din Āmulī’s mathematical work Khulasatul Hisāb and was written in Persian in 1681 A. D. The copies of the manuscripts are available in the Asiatic Society of Bengal, Bankipur, British Museum, Azad Library (Aligarh) and Salarjung Library, Hyderabad. His Risāla dar Jawab i - Sawāli on geometry in question answer form and Risalah - i - Arsmatiqi on properties of numbers are still available in the Rampur Library and Saidiyah Library (Hyderabad). He wrote Taqvim Lutfī, on almanac
and *Tarjuma Kitāb Suwar i Kawākib*—a commentary on the celebrated astronomical work *Suwaru'l Kawākib*. The manuscript is available in Rampur Rida Library, U. P. and Azad Library Aligarh.

Hāji Khalu'lllah, son of Amanu'lllah and brother of Mulla Murshid Makramat Khan in the beginning of seventeenth century A. D. (died in 1649) wrote a commentary on the work of mathematics entitled *Sharḥ i Kitāb - i - Haji Kalil*. A copy is available in the Rampur Library.

Sh. Muḥammad (seventeenth century A. D.), son of Sh. Muḥammad Said, flourished under emperor Aurangzeb (1659 - 1709). He wrote in Arabic *Sharḥas Sirājīyyah*, an incomplete commentary on a Sajavandi’s algebrical treatise known as Sirajiyah. The manuscript is available in the Asiatic Society of Bengal.

Dharma Nārāyan ibn Kalyānmal Kayath wrote a Persian commentary in 1663 - 64 at Etawah on the *Līlāvati* under the title *Badū’i - i Funūn* and dedicated to Alamgir (1659 - 1709). The copies of manuscripts are listed by C. A. Storey. This shows that the *Līlāvati* received recognition among the Mughal emperors. Manuscript copies of Faiz’s version are found deposited in the British Museum (one copy), India Office Library (three copies) and John Rylands Library in Manchester (one copy) to mention a few. Another version *Dastūr al - Ḥisāb : Tarjuma - i - Līlāvati* was prepared by Amin Shaikh Muhammed Said in 1678. The incomplete Manchester copy has been translated by Winter and Mirza, the work contains a selection of examples taken from the *Līlāvati*. The examples include problems on investigation of mixture, rule of three, inverse proportion, compound proportion etc. and concern primarily business translation.

Khwāja Bahādūr Ḥusain Khān Bahādur flourished during the reign of Aurangzeb and later went to the South with Quich Khān. He learnt astronomy and astrology under S. ‘Alavi Khān Zubadatu’l Munajjimin Ŧalīqānī. He is known for his two works, viz. *Sharḥ - i Zīj - i Nizāmī* (commentary on *Zīj - i Nizāmī*) and *Zīj - i Nizāmī* (astrophysical and astronomical table). The scholar has made studies of both Indian and non-Indian works. The copies of both the works are available in the State Central Library.

Nand Rām, son of Hiranand Ka’isth flourished during the reign of Mughal emperor Aurangzeb (1659 - 1709) and wrote a work on accountancy, *Ain - i - Siyāq* in 1680. One copy of the manuscript is available in the State Central Library, Hyderabad. M. Husain s. o. Khaļilullah (d. 1696) was born at Bijapur and studied under M. Zubair at Bijāpuri. He was appointed principal of Madrasah - Mahmūd in Bidar by Aurangzeb in 1686. He produced *Ujalatur Rub* in Arabic which deals with application of quadrant for recording various astronomical data. The manuscript is available at Saidiyah Library, Hyderabad.

Rājā Jayasimha (1693 - 1743) flourished under the patronization of Maḥammad
Shāh (1719 - 1748) and tried to rectify and improve the almanacs already constructed by his predecessors. He started organizing new observations with the help of the Muslim, Hindu and European experts. After seven years of observations in Delhi, Jaipur, Mathura, Benaras, and Ujjain, he deputed Padre Manoel with some competent hands to Europe who brought back with them the astronomical tables of De la Hire. These materials are compiled in his Zīj - i Jadid - i Muḥammad Shāhī, which was completed in 1727. The manuscript is available at the Oriental Library, Bankipur and British Museum. Under his patronization, Samrāṭ Jagannātha translated Ptolemy’s Syntaxis as Siddhāntasāra Kaustubha, Euclid’s Elements as Rekhāgaṇita. Kewal Ram (Gujrathi Brahmin) translated De la Hire’s table as Jai Vinod Vibhag Sāraṇī, Ulugbeg’s tables as Tārā Sāraṇī. Puḍarik Ratnākara, a Maharastrian Brahmin wrote Jai Singh Kalpadrum dealing with Purānic facts.

Muḥammad Zaman Fayyad, son of M. Sadiq al - Anbalaji ad-Dehlawi wrote in 1718 his Ghayat - i Juhdu'l Ḥisāb. The manuscript is available in the Bankipur and Rampur Libraries. He was a native of Ambala and later on resided at Delhi. He wrote several other books in mathematics and astronomy. His Tahrīru’l ʿAshkāl li Hal - i Sharh - li ʿAshkāhu’t Ta’sis li ʿUsī is a super commentary on the commentary by Tusī on the ʿAshkahu’t Ta’sis, a geometrical work of Shamsu’d Din M b. Ashraf Husaini. The manuscript is available in the Rampur Library.

‘Imāmu’d - din Ḥusain (b. 1701), the eldest son of Luṭfūllāh Muhandis was a well-known astronomer. He wrote many works on astronomy of which mention may be made of at - Ta’ liqāt ‘alā Sharhī’l - Mulakhhkhasī’l Chagmini (commentary) on the Al - Mulakhhkhas fi’il - Hai’al of Qādi Zūdah ar - hūmī and At - Taṣrīḥī sharhī’ Tashriḥ (commentary on Taṣrīḥū’d - din Aftāk of Bahā’ud - din ’Āmulī).

Mīrza Khairullāh Muhandis (c. 1700 - 1740), the second son of Luṭfūllah Muhandis of Lahore and nephew of ‘Ata’ Allāh Rushdi (c.1634), was astronomical adviser to Jayasiṃha (fl. 1693 - 1743) and wrote a Sharḥ on the latter’s Zīj i Muḥammad Shāhī. He also translated a copy of Almagest and wrote a commentary on it. A manuscript of Almagest with his commentary is available at the Raza Library, Rampur.

Abū’l Khairū’llāh, son of Luṭfūllah Muhandis was appointed the head of the observatory at Delhi by emperor Mohammad Shāh in 1718. His Taqribu’t Tahrīr, is a Persian translation of Naṣīrūd-din’s Arabic version on Ptolemy’s Almagest. He compiled with the help of Nizāmu’d-din al-Barjandi’s commentary on Ṭusī’s above work. The manuscript is available at the Bankipur Library. He wrote another commentary on the Zīj-i-Muḥammad Shāhī.

Mulchand, son of Harihar Prasad, flourished during the reign of Muḥammad
(1719-1748) ruler of Delhi. His Hisab Namah, a treatise on arithmetic was written in Delhi. One copy of the manuscript is available in State Central Library.

Anand Ram Mukhlis, son of Rajah Mardi Ram of Allahabad, flourished during the reign of Muhammad Shah (1719-1748). His work Dasturul Amal chiefly dealing with accountancy was written in first half of eighteenth century in Persian. It contains informations on weights and measures, zodiacal signs, Hindu science and sastras in tabulated forms. He quoted profusely about his teacher Mirza Bedi in the work.

Inderman, a native of Hisar wrote his Dastur-i-Hisab in 1767. It is a treatise in five maqulah and a Khatimah. One copy is available at Bankipur Library.

Muhammad Barkat flourished in Lahore in 1782 A.D. and was well-known for his Sharh Tahiri-u usuli’l Handasat-i wa’l-Hisab, a commentary in Arabic on the first book of Euclid and Al-Hasbiyah’ala Uqidas, a gloss on the Euclid. The manuscripts are available in the Osmania University Library.

Khwajah Muhammad was a native of Hyderabad and dedicated his arithmetical work, Mir’atu’l Hisab in 1786 to Mumtazu’d Daulah M. A. ‘Zamu’d-din Khan Bahadur Muzaffar Jung, commander in chief of Nizamud Din Mir. Nizam ‘Alikhan Fath Jung, ruler of Hyderabad. The manuscript is available at the Azad Library, Aligarh, State Central Library, Rampur Library and Mashriqi Kutub Khanah Salar Jung, Hyderabad. He wrote also a commentary Sharh-i-Khulastu’l Hisab on the Khulasatu’l Hisab of Baha’ud-Din ‘Amuli’. The manuscript is available in the State Central Library.

Raushan ‘Ali (flourished second half of the eighteenth century) was born at Jaunpur. He taught at Calcutta Madrasah and Fort William College. He wrote a number of works in mathematics and other subjects. Some of these works are Risalah fi Jabr wa Muqab-lah (on algebra), Risalah-i Hisab (a treatise on arithmetic) Tarjumah-i Khulasatu’l Hisab (a translation of Baha’ud-din Anuli’s mathematical treatise). The manuscript is available in Rampur Library.

Karim Baksh made a selection from a larger treatise, Umutul Hisab for a Deccan Prince Arastu Jah. Three copies of the manuscripts are available in the Sa Idiyah Library, Hyderabad.

Nawab Shamsu’ul Umara Fakhrud-din Khah Bahadur (b. 1785) was a descendant of Faridu’d-din Mas’ud al Ajudhany. His grandfather migrated to Hyderabad and was appointed an officer under Asaf Jah Nizam, first founder Nizam of Hyderabad (died in 1748). He took interest in propagating western knowledge to India. He wrote two works, viz. Risalah der Bayan i Amal-i Qite, a treatise on the cons-
struction of the sector and Sham su’l Handasah, a work on geometry, mensuration and trigonometry. Both these manuscripts are available in State Central Library, Hyderabad.

M. Husain Isfahani Landani, son of S. ‘Abdu’l-‘Azim Isfahani Landani, flourished during the days of Asif’ul-mulk Sikandar Jah Bahadur. He wrote his Risālah-i Hai‘at-i Angrezī in 1797 on European astronomical system specially English and French. The manuscript is available in State Central Library, Hyderabad and Rampur Library, U.P.

Sayyid Nuru’l Asfiyah Aurangabad (c. 1800) was born at Aurangabad. He lived for a considerable time with Nawab ali Khân at Karnal and later on shifted to Hyderabad and joined the service under Nawab Shamesu’l Umara. He wrote Risālah-i-Nuru’l Hisāb, a treatise on arithmetic. The manuscript is available in the State Central Library, Hyderabad.

Sh. Aḥmad b.m. Maghribi Tilimsani al-Ansari as-Sa’imi (c. 1814) was attached as collector in the Department of Revenue of Madras. He composed several treatises on mathematics and astronomy. His A’ zamul’-Hisāb is a treatise on mathematics, now available in the State Central Library. The Zubdatu’l Hisāb is another mathematical treatise available in Asiatic Society in four chapters dealing with arithmetic, measurement, finding an unknown quantity and some essentials relating to arithmetic. He perhaps wrote another work Mir’atu’l-‘Alam on mathematics. The manuscript is available in the State Central Library.

Abu’l Qāsim (Ghulam Husain), son of Fath M. Al-karbala-i wrote his Jama’i Bahādur Khānī in 1834. He was born at Jaunpur in 1790-91 and had his lesson in mathematics under his father and some contemporary scholars in mathematics. He spent most of his time with the princes of Benaras and Murshidabad. The work is devoted to mathematics and astronomy in six chapters, viz. science of geometry, optics, arithmetic, practical geometry dealing with the measurement and division of circle, etc., heavenly bodies, horoscope and calendar. The copies of manuscripts are available in the Asiatic Society of Bengal, State Central Library, Salarjung Library, Hyderabad. He wrote several other works, viz. Sharzha Tahrīr-i Uqīdās (commentaries on Euclid) and al-Miṣṣīṣ (commentary on Almagest of Ptolemy). Anīsu’l-Āḥbāb fi Bayān-i Masā’il-i Uṣūrīs (commentary on the Bahā’ud-dīn ‘Āmuli’s treatise on Sufa’īhah), Iṣṭiḥāṣū’l Taqwīn (on compilation of almanacs) and Zīj-i-Bahādur Khānī (on astronomical tables).

4. Trend of Indo-Persian Literature

The Persian and Arabic literature were produced mostly under the patronage of Mughal rulers. Many standard works were brought from outside India. Some of these are Khulāṣtu’l Hisāb of Bahā’ud-dīn ‘Āmuli (c. 1547-1621) written originally in Arabic in Iran, Tahrīr-i-Uqīdās al Miṣṣīṣ—Arabic version of Euclid’s Elements.
and Ptolemy’s *Almagest* by Naṣīru’d-dīn aṭ-ṭusi etc. besides some others on accountancy, which attracted attention of many Indian scholars.

Attempt has been made to translate and write commentaries on these texts. Similar attempts have been tried to make translations of *Bṛhat-samhitā*, *Lilāvati*, and *Bijaganita* in the period, but very few attempts have been made to make a comparison with the available knowledge in Sanskrit sources. These were written mainly for readers of Persian who knew no other language and had no access in standard Sanskrit, Arabic and Persian treatises in mathematics. Only a partial attempt has been made by Muṇīśvara and Kamalakara, Jagannātha Paṇḍit and Rājā Jayasimha to make a synthesis of the available Indian knowledge and that of Ptolemy and Euclid. The real success has been achieved by Rājā Jayasimha who used the services of great Sanskrit scholars having knowledge of Sanskrit, Persian, Arabic and European works which helped him to modernize the observatories in Delhi, Jaipur, Mathura, Banaras, Ujjain and left two almanacs in Sanskrit and one work in Persian.2

5. CONCLUSION

To sum up, the present survey gives an idea of the Indian literature on mathematics during the period. It is by no means complete. The account gives both Hindu and Islamic traditions in Índia as well as their activities in the form of writing commentaries on older Indian and some Persian texts, which helps us to some extent to assess the trend of literature. The activities of the Indian scholars in mathematics and astronomy also attracted the attention of European scholars, viz., Giovanni Dominique Cassini (1691-1699), Le Gentil (1772), Robert Barker (1777), Joseph Tieffenbacher (1785-1789), Bailey (1878), William Jones (1790), Samuel Devis (1790-1792) and John Bentley (1799), who tried to make an assessment of Indian activities by writing translation of the texts, writing articles in French, Latin, German language. Sen8 has made a résumé of these activities. But the assessment of the actual contribution in the period deserves more intensive research. This is very important because this will help us to assess correctly the proportion of cultural interdependence in the field of mathematical knowledge.

NOTES AND REFERENCES


4 The date of *Karana-paddhati* has been suggested as 1732 A.D. by K. V. Sarma and others.

