Sanskrit Scientific Texts in Indo-Persian Sources, with special emphasis on *siddhāntas* and *karaṇas*

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1 *Introduction*

The pioneering work of Prof. David Pingree on the transmission of ancient Indian astronomy into Islamic countries in the early period is quite well known.[1] We may mention here briefly that at least two Indian *siddhāntas* are considered to have been transmitted during or shortly after Caliph al-Manṣūr's reign (754–775): namely, the *Āryabhaṭasiddhānta* of Āryabhaṭa (born in 476 A.D.) and a work (possibly entitled *Mahāsiddhānta*) of the school of the *Brāhmasphuṭasiddhānta* (written in 628 A.D. by Brahmagupta, born in 598). The latter was translated from Sanskrit into Arabic by Muḥammad ibn Ibrāhīm al-Fazārī and colleagues in about 775 as the *Zīj al-Sindhind*, or *Zīj al-Sindhind al-Kabīr*.[2] The *Sindhind* tradition was employed by al-Fazārī's contemporary Yaʿqūb ibn Ṭāriq (d. 796) and particularly by Muḥammad ibn Mūsā al-Khwārizmī (d. 850) in his *Zīj*, through which it spread even to the scholars of Muslim medieval Spain (*al-Andalus*).[3]

So far as the genre of Indian astronomical literature called *karaṇas* is concerned, we may cite here the *karaṇa* of Brahmagupta, the *Khaṇḍakhādyaka* (epoch 665), which was translated or adapted into Arabic in 735 in Sind (India) as *Zīj al-Arkand*,[4] two excerpts from which are known as *Zīj al-Jāmiʿ* and *Zīj al-Hazūr*.[5] The latter was compiled in Qandahar (formerly in India, now in Afghanistan).

[1] [Pingree 1981], wherein many of his other works on the subject are cited.

[2] [Pingree 1981, 18–19, 21 n. 51]; [Sezgin 1978, 16–19], and for Indian sources *ibid.*, pp. 116–20.

[3] [Pingree 1996a].

[4] [Pingree 1981, 33]; see also [Sezgin 1978, 120].

[5] [Sezgin 1978, 120] quotes (in n. 3) the Arabic text of the relevant passage from *Kitāb ʿIlāl az-Zījāt* by al-Hāshimī (fl. 9th/10th c.), who reported this information.

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For the record, we may also mention here that the Arabic translation of Vijayananda's[6] *Karaṇatilaka*[7] (compiled in 966 A.D.), carried out by Abū al-Rayḥān al-Bīrūnī (973–1048), is extant even today in the private collection of Dargāh Pīr Muḥammad Shāh in Ahmedabad (India).[8] Its Arabic title is *Ghurrāt al-Zīyāt.* The Arabic text with a facsimile of the manuscript has been published by N. A. Baloch,[9] and an English translation by F. M. Quraishi.[10]

2 *Astronomy in Muslim India*

In order to appreciate the astronomical context of this period, we summarise in this section the development of astronomy during the pre-Mughal (1191–1526 AD) and Mughal (1526–1857) eras of Indian history. Here we are confining ourselves only to Arabic and Persian sources. It is clear that during this time, the above-mentioned trend of transmission reversed its direction: sources from the Islamic scientific traditions in the West Asia found their way to India.

Astronomical sciences developed in the Islamic countries, particularly during the ʿAbbāsid Caliphate and its successors, passed from the early assimilation stage to the creative stage[11] which in turn culminated in the establishment of Naṣīruddīn al-Ṭūsī's Marāgha school of Islamic theoretical astronomy.[12] Is-

[6] In the Arabic text the name is Bijyānand son of Jayānand.

[7] The translator, al-Bīrūnī, uses the title *Zīj-i Bijyānand.*

[8] It is a unique manuscript; no other copy has been found to date. Furthermore, the Sanskrit original seems to have been lost. The manuscript was first discovered by M. Nizam [Nizam 1929–30].

[9] [Baloch 1973], with an excellent introduction (of 74 pages), and appended excerpts from other works of al-Bīrūnī wherein he refers to the *Karaṇatilaka*; namely, *Kitāb Taḥqīq mā li'l-Hind* (*Indica*), *Al-Qānūn Masʿūdī*, *Risāla Tamhīd al-Mustaqarr*, and *Ifrād al-Maqāl.*

[10] [Quraishi 1978] presents an English translation of the Arabic text with calculations, notes, and references (the Arabic text itself is also appended), but without mentioning the *first* study of the *Karaṇatilaka* of [Rizvi 1963–65]. However, he refers to the discovery of this manuscript of [Nizam 1929–30].

[11] [Sezgin 1978] deals expertly in his Introduction with the assimilation of scientific astronomy (Sec. D, pp. 16–19) and with the beginning of the 'creative' period (Sec. E, pp. 19–36).

[12] Research on this school was initiated by E. S. Kennedy and his colleagues. It is based particularly on the Arabic sources pertaining to the critique of

lamic practical astronomy is embodied in the *Zīj*es and writings on astronomical-mathematical instruments.[13] It was transferred to India during the aforementioned periods, when scholars from West and Central Asia (including Iran) flocked to the courts of Indian Sultans and Mughal emperors. That exodus was a boon to the development of Islamic astronomy in India. The standard astronomical and mathematical sources in Arabic and Persian accompanied those scholars, and multitudes of those primary sources are still extant in various Indian libraries. For instance, we possess in manuscript form treatises on both theoretical and practical astronomy by Naṣīruddīn al-Ṭūsī, Quṭbuddīn Shīrāzī, Maḥmūd al-Chaghmīnī, Jamshīd Ghayāthuddīn al-Kāshī, Ulugh Beg, ʿAlā'uddīn ʿAlī Qushchī, and Bahā'uddīn al-ʿĀmilī, to name just a few.[14] All this material and the patronage of the Islamic astronomers by Indian rulers led to the development of Indo-Islamic astronomical literature, particularly in the Indo-Persian language.[15] For instance, the following *Zīj*es may be noted:[16]

1. *Zīj-i Nāṣirī*, dedicated to Naṣīruddīn Maḥmūd bin Sulṭān Shamsuddīn Iltutmish (ruled in Delhi 1246–65), the author being Maḥmūd bin ʿUmar (MS in Tabriz, Iran).

2. *Zīj-i Jāmiʿ Maḥmūd Shāhī Khiljī*, compiled sometime during 1438–60 by an anonymous Indian scholar (MS in Oxford), dedicated to Sulṭān Maḥmūd Shāh Khiljī (reigned 1435–69).

Ptolemaic astronomy; cf. [Saliba 1994], in which relevant articles on this topic are referenced.

[13] Cf. [King 1987], the standard work particularly on Islamic astrolabes. See also [Ansari & Ghori 1985–87], especially the Introduction (pp. 215–16). We may add, for instance, that a large number of copies of the famous treatise of al-Ṭūsī, *Twenty Chapters on the Astrolabe*, are extant in India and Pakistan; this work was even translated into Sanskrit. Moreover, a couple of manuscript copies of the standard work on the astrolabe by al-Bīrūnī, *Istiʿāb al-Wujūh al-Mumkina fī Ṣanʿat al-Asṭurlāb*, exist in the libraries at Rampur and Aligarh Muslim University.

[14] Cf. [Ansari 1995], in the appendix of which we have listed almost all the astronomical treatises and their commentaries available in manuscript collections of Indian libraries.

[15] Cf. [Ansari 1997/2001], in which we have presented the first study on this topic.

[16] Cf. [Ghori 1985], [Ansari 1995, 281–4]. See also '*Note added in proof*'.

3. *Tashīl Zīj-i Ulugh Beg*, a commentary on Ulugh Beg's Tables (ZUB) by Shaykh Chānd ibn Bahāuddīn, the court astronomer of the emperors Humāyūn (reigned 1530–56) and his son Akbar (reigned 1556–1605). It may be noted that Akbar ordered during his reign the translation of ZUB into Sanskrit, which was carried out by a team of Muslim and Hindu scholars. One of its copies is extant in the City Palace Museum of Jaipur (India).

4. *Zīj-i Shāhjahānī*, dedicated to the emperor Shāh Jahān (reigned 1628–58), compiled by the court astronomer Farīduddīn bin Masʿūd Dehlawī (d. 1630). The emperor's Hindu court astronomer Nityānanda translated it into Sanskrit. One copy of this translation is in the City Palace Museum (Jaipur); three manuscript copies are in the Khaṣ Mōhar Collection (Jaipur).[17]

5. *Zij-i Raḥimi*, compiled also by Farīduddin Dehlawī in about 1628. Its unique manuscript is extant in the Holy Shrine Library in Mashhad (Iran).[18]

6. *Zīj-i Muḥammad Shāhī* (ZMS), compiled for Maharaja Sawai Jai Singh (1686–1743) and dedicated to the emperor Muḥammad Shāh, has already been treated elsewhere.[19] This is the most important Zīj of Mughal India. In fact it replaced throughout much of the Islamic world (e.g., Iran and Central Asia) even the standard *Zīj-i Ulugh Beg* prepared in the fifteenth century at Samarqand. ZMS was compiled by Mirzā Khayrullāh Muhandis (d. 1747) who belonged to a distinguished family of mathematicians. (The critical edition of the Persian text of ZMS will appear shortly.)[20]

7. *Zīj-i Ashkī*, by Kundan Lāl Ashkī, son of Mannū Lāl Falsafī, written in 1816. An autograph manuscript of 62 pages is in

[17] For details about this Sanskrit translation, see [Ansari 1995, 277] and [Pingree 1999, 77].

[18] For the first short description, see [Ghasemlou & Naderi 2002].

[19] Cf. [Ghori 1985, 36–41]; [Ansari 1995, 283]. For its relation to de La Hire's tables, see [Pingree 1999] and [van Dalen 2000].

[20] See the forthcoming series of articles by us on 'ZMS and its Significance in the Zīj-Literature', to be published in the *Indian Journal of History of Science*.

Hyderabad. This *Zīj* is written in the traditional style.

8. *Zīj-i Bahādurkhānī*, by Ghulām Ḥusayn Jaunpūrī, written in 1838 and printed in 1855 in Benares. It is largely based on the *Zīj-i Muḥammad Shāhī*. Evidently it follows the style of Central Asian *Zīj*es.[21]

Besides the astronomical and mathematical tables, a number of treatises particulary on astrolabe were also written.[22] In fact, a whole school of astrolabe makers in India sprang up, which is known as the Lahore astrolabists, the manufactured specimens of which are to be found through out the world.[23]

A by-product of the promotion of the science of astronomy during the period in question was the interaction between the scholars of traditional Indian astronomy (the Sanskritists) and those of Islamic astronomy (scholars of Arabic-Persian). That interaction gave birth to the translation of several Arabic-Persian sources into Sanskrit: for instance, the translation of *Zīj-i Ulugh Beg* by a team of Muslim and Hindu scholars during Emperor Akbar's reign, or that of the *Taḥrīr al-Majisṭī*, the recension of Ptolemy's *Almagest* by Naṣiruddīn al-Ṭūsī.[24] Without going into the details of this interaction,[25] we attempt in the following an account of the reverse trend: that is, the translation of Sanskrit texts into the Indo-Persian language.

3 *Persian Translation of Scientific Texts in Sanskrit*

3.1 *Mathematical Texts*

[21] [Ghori 1985, 42–4]; [Ansari 1995/96], 'Ghulām Ḥussain Jaunpūrī and his Zīj-i Bahādurkhānī.

[22] We may mention here particularly a Sanskrit treatise on the astrolabe, translated or adapted from some Arabic or Persian work, entitled *Yantrarāja* ('King of Instruments'), composed by Mahendra Sūrī in about 1370. Mahendra was a court astrologer of Sulṭān Fīrūz Shāh Tughlaq (reigned 1351–88). A number of commentaries were written on this text, of which there are extant about 100 manuscript copies [Sarma 1999, 147]; see [Ohashi 1977, 211] for details.

[23] Cf. Sarma, S.R. (1994 a,b)

[24] The title of this Sanskrit translation is *Samrāṭ Siddhānta*; it was carried out by Jagannātha (b. 1652), and was commissioned and/or sponsored by Maharaja Sawai Jai Singh [Sen 1966, 90].

[25] See [Ansari 1995], especially pp. 276–9; see also [Sarma 1998].

For the sake of completeness, we may mention two non-astronomical mathematical works of Bhāskara II (b. 1114) which, as is well known, were translated into Persian in medieval India:

1. *Līlāvatī*, translated by the famous scholar Abu'l Fayḍ Faydī (1547–96) in 1587 at the instance of Emperor Akbar. A large number of manuscript copies are extant in the libraries of India and Pakistan. The text was published lithographically from Calcutta in 1827, 1832 and 1854. It was also translated into English by J. Taylor (published from Bombay, 1816) and partly by H. T. Colebrooke (London, 1817).[26]

2. *Bījagaṇita*, translated by ʿAtā'ullāh Rushdī or Rāshidī (son of Aḥmad Maʿmār, the architect of the Taj Mahal), dedicated to the emperor Shāh Jahān (reigned 1628–58) and composed in 1634–5. The English translation of the Persian text was made by E. Strachey, London 1813.[27]

3.2. *Astronomical Texts*

3.2.1 *Astrological-astronomical Works.* We know of two such texts which were translated from Sanskrit into Indo-Persian in the Sultanate (pre-Mughal) period:[28]

1. *Dalā'il-i Fīrūzī*, translated by ʿIzzuddīn Khālid Khānī (or Khafī) by the order of Sulṭān Fīrūz Shāh Tughlaq (1351–88). The author 'was [then] one of the poets and *munshīs*. It was an astrological tract in verse, and dealt with the rising and setting of the seven planets, and their good and evil import, and of auguries and omen.' The translation was seen in Lahore in 1591 by ʿAbdul Qādir Badaoni (Badāyūnī), who is the author of this report.[29]

2. *Tarjumah-i Bārāhī* or *Kitāb Bārāhī Sanghtā*, a translation of Varāhamihira's *Bṛhatsaṃhitā*, by ʿAbdul ʿAzīz Shams

[26] [Sen et al. 1966, 25–26]; [Storey 1972, 4–5].

[27] [Sen et al. 1966, 20–22]; [Storey 1972, 5].

[28] [Jalali & Ansari 1985].

[29] [Badaoni 1973, 332]. Badaoni (1540–1615) was a famous translator of Sanskrit classics (for instance, the *Mahābhārata*, the *Rāmāyaṇa*, and a *History of Kashmir*) into Persian at the instance of Emperor Akbar.

Thānesarī, by the order of Sulṭān Fīrūz Shāh Tughlaq. Six manuscript copies of the Persian text have been found by us so far: namely, 2 in Aligarh Muslim University, 1 in the India Office (London), 1 in A. P. State Central Manuscript Institute/Library (Hyderabad), and 2 in the Shīrānī collection at the Punjab University Library (Lahore).[30]

Another translation of the same Sanskrit text with the title *Nujūm Mālā* was composed by Pandit Rāj Bhīm at the instance of Nawāb Ḥaydar Beg Khān Nuṣrat Jang in 1789–90. Monzavi lists four manuscripts (3 in Lahore, 1 in Karachi).[31] One manuscript of the same is in the Subhanullah Collection, MS 200/6, in M.A. Library (Aligarh Muslim University).

Recently we have found another manuscript of the Persian translation of the *Bṛhatsaṃhitā* by Kirpa Nath Khatri ibn Rai Lahorimal of Sialkot district in Punjab, entitled *Zā'ichā Nāmah*, in the Library of Rajasthan Institute of Persian and Arabic (Tonk). There are two manuscripts, No. 3205 (copied in 1824) and No. 3267 (copied in 1822).

3.2.2. *Karaṇas.*

1. *Zīj-i Muẓaffarshāhī*, written during the reign of Sulṭan Muẓaffar Shāh II (1511–26), son of Maḥmūd Shāh Begarah Gujrātī. The unique anonymous manuscript copy of this *Zīj* is in the Shīrānī Collection, Punjab University Library, Lahore (Pakistan), as MS 6261/1, with 34ff. It was composed in 931 AH/1525 AD. The text of the *Zīj* has been published by Aftāb Asghar [Asghar 1980], who conjectured that the scribe was one Gul Muḥammad. In the colophon, a sort of title is noted by the scribe, viz., *'al-Shams w'al-Qamar'*, which in turn is presumably taken from the Quranic verse: *'Ash-Shamsu w'al-Qamaru bi Ḥusbān'* (55:5). The present title, *Zīj-i Muẓaffarshāhī*, is given by Ḥāfiẓ Maḥmūd Shīrānī, who argued that according to the *Zīj* tradition it may be named after the patron in whose reign the work was compiled. See 'Note added in proof'.

[30] See details in [Jalali & Ansari 1985].

[31] [Monzavi 1983, 305–306].

The author of the *Zīj* mentions in an introductory note that this *Zīj* is based on a compilation by Indian scholars (*Ḥukamā'-i Hind).* Although the author quotes no source, on the basis of the Sanskrit technical terms used in the concise prescriptions for calculating the planetary parameters, we have identified it as a *karaṇa.* The text is divided into ten short chapters, each of which consists of six or seven sections (*faṣl).* There are chapters corresponding to each planetary body, the moon, and its nodes; the last chapter is on miscellaneous topics. (An English translation of this work is currently in preparation.) The importance of this text lies in the fact that it is the second Persian exemplar of the pre-Mughal period which was translated from Sanskrit and which is extant today—the first being the translation of Varāhamihira's *Bṛhatsaṃhitā*, as mentioned above.

2. *Sharḥ Frankūhal* (or *Frankōhal*) is a commentary on the *Karaṇakutūhala*, written in 1183 AD by Bhāskara II.[32] The commentary is anonymous; it was composed in 1809 Bikrāmī/1752 AD and its unique manuscript of 159ff, No. sh 520 bhā, is extant in the Punjab Public Library (Lahore).[33]

3. *Karaṇkatū(ō)hal* is another anonymous manuscript extant in the collection of Punjab University Library (Lahore). It was copied by Gul Muḥammad, who also copied the *Zīj-i Muẓaffarshāhī* (see No. 1 above). Therefore this manuscript copy (No. sh /3/102/6261, of 68ff) may be dated to the sixteenth century. It has not been identified by the cataloguer Monzavi.[34] We conjecture that it may be a Persian translation of Bhāskara's *Karaṇakutūhala.*

3.2.3. *Siddhāntas.* The practical Islamic astronomy developed during the medieval Indian period was based solely on the Central Asian *Zīj* tradition, as briefly delineated in section 2 above, and we have not found any reference to date for the direct utilisation of *siddhāntic* (theoretical) astronomy during the 12th–

[32] [Sen et al. 1966, 31–32].

[33] [Monzavi 1983, 289–90]. See also [ʿAbbāsī 1963, 270].

[34] [Monzavi 1983, 363] (entry no. 690). Monzavi does not identify the author of the Sanskrit original. See also 'Note added in proof'.

17th centuries by Arabic/Persian-knowing Indian astronomers.[35] However, this situation changed at the close of the 18th century and during the first half of the 19th century. In the following we present our findings on this shift of interest and the resulting transmission.

1. One of the very few commentaries on *Zīj-i Muḥammad Shāhī* (compiled in the 18th century and sponsored by Maharaja Sawai Jai Singh) is by an Indian scholar ʿAbdullāh bin ʿAẓmuddīn bin Muḥammad Khān, called Mahārat Khān (fl. 18th c.). A number of its manuscript copies are available in various libraries.[36] The title of the commentary is *Tashīl Zīj-i Muḥammad Shāhī*; it is a sort of astronomical ready-reckoner with a large number of auxiliary tables.

   Here we are particularly interested in MS No. 3641 of the Library of the Arabic and Persian Research Institute of Rajasthan (Tonk, India). In this manuscript we find an appendix to the subsection 'Crescent Visibility according to the method of Indian scholars (*Ḥukamā'-i Hind)*'.[37] It comprises a number of chapters, each of which consists of a number of sub-sections (*faṣl)*.[38] Their headings are: About crescent visibility; true daily motion of a planet (*karaṇabhukti)*; appearance and disappearance of planets; knowing about the lunar and solar eclipses; about solar ingress into a zodiacal sign (*saṅkranti)*, and about the ascendant (*spaṣṭalagna*). At several places in the text, the scribe of this appendix (not Mahārat Khān) named his sources. In Persian orthography they are given as: *Grahalāghū(va)*, *Siddhāntmañjarī*, *Siddhāntdinchandrī*, *Bhāstī* and *Siddhāntacharat(t)ar*; the last one has not been identified. At one place he names also '*ṣāhib-i* [author of] *Līlāvatī*', i.e., Bhāskara II. Besides these

[35] However, the converse was not true. For instance, the Hindu court astronomer of Emperor Shāh Jahān, Nityānanda, in his *Sarvasiddhāntarāja* (written in 1639) employed Islamic planetary models and even adapted Islamic mathematical astronomy for the framework of Indian *yuga* astronomy. See details in the very interesting paper [Pingree 1996b].

[36] See [Storey 1972, 94] for details.

[37] We are at present unable to compare other manuscript copies of Mahārat Khān's commentary to find out whether or not such an appendix is included in any other copy.

[38] Tonk MS 3641, ff. 150–56.

Sanskrit sources he also used the *Zīj-i Sulaymānjāhī*.[39] We have identified most of his Sanskrit sources as follows:

1.1. *Grahalāghava*, also known as *Siddhāntalāghava* (written in 1520), is the very famous work of Gaṇeśa Daivajña (b. 1507), son of Keśava Daivajña of Nandīgrāma (near Bombay). It is actually a *karaṇa*, since without using trigonometrical calculations, it gives simple arithmetical methods for carrying out astronomical calculations. It is in use even today in many Indian states by calendar (*pañcāṅg*) makers.[40]

1.2. *Siddhāntamañjarī* is an elementary treatise on astronomy, authored by Mathurānātha Vidyālaṅkāra (ca. 1609). Note that two other titles of this treatise are *Suryasiddhāntamañjarī* and *Ravisiddhāntamañjarī*.[41] The author of the appendix mentions also that it is based on the '*Sūraj Siddhānt*'.

1.3. *Siddhāntdinchandrī* is known to us simply as *Dinācandrikā*. The author was Rāghavānanda Cakravartin (ca. 1599). It is actually a set of astronomical tables with brief instructions for the construction of a calendar.[42]

1.4. *Bhāstī*, i.e., *Bhāsvatī*, is a well known *karaṇa* written in ca. 1099. It is based on Varāhamihira's work and the *Suryasiddhānta*. The author is Śatānanda who lived in the sacred town of Pūrī. With the rules given in this work, calculations for the occurrence of eclipses can be carried out accurately. In fact, our author of the appendix mentions this source in the section 'Lunar and Solar Eclipses', especially for calculating the position of the first lunar node (*Rāhu*).[43]

[39] See section 2.7 below. In two marginal notes he mentions Imāmuddīn (Riyāḍī) and (Mirzā) Khayrullāh Muhandis also. For the former, cf. section 2.1 below and for the latter n. 52.

[40] Cf. [Sen et al. 1966, 64]; also [Bose et al. 1971, 100], and for greater detail [Rao 2000, 158–69].

[41] [Sen et al. 1966, 143].

[42] [Sen et al. 1966, 175].

[43] [Sen et al. 1966, 193–4].

The author of the appendix illustrates his method of calculations by examples in which the years 1257, 1258 and 1259 AH appear (that is, the years 1841–43 AD), which thus could be taken as the time of composition of this appendix, and for that matter, this copy of the commentary.[44] Therefore we assume that the author of this appendix is the scribe of this copy of the commentary. The city of Lucknow is mentioned in several places. The copious use of Sanskrit terminology and methods indicates the author's in-depth knowledge of ancient Indian astronomy and its Sanskrit sources.

2. Apart from the above-mentioned appendix, our survey has brought to light a number of *Zīj*es in Persian which are either direct translations or adaptations of well-known *Siddhāntas*. We list them in the following.[45]

   2.1. *Zīj-i Āṣaf Jāhī* (18th c.). It purports to be based on the *Sūryasiddhānta*; excerpts from it are found in a *Biyāḍ* (a Notebook) of the famous mathematician Imāmuddīn Riyāḍī (d. 1732), son of Luṭfullāh Muhandis. The manuscript of this Notebook is in the Salar Jung Museum Library (Hyderabad). This *Zīj* is dedicated to the first ruler (*Niẓām*) of Hyderabad, Niẓām al-Mulk Āṣaf Jāh (reigned 1720–48).[46]

   2.2. *Zīj-i Niẓāmī*, (1780), compiled by Khwājah Bahādur Ḥusayn Khān alias Sayyid Abu'l Fatḥ.[47] It is dedicated to the fifth ruler of Hyderabad, Nawwāb Niẓām ʿAlī Khān (reigned 1762–1802).[48] There are two

[44] Note that the earliest manuscript of this commentary by Mahārat Khān is in Leiden and is dated 1770, which is chronologically followed by another manuscript copy in the Mullāh Fīrūz collection (C. R. Cama Research Library) in Bombay, dated 1791; see [Storey 1972, 94].

[45] The following set of Indian *Zīj*es has been described in some detail in [Ansari 1995, 283–4]. For lack of space we can give here only a little more information; we intend to give a detailed account of all these *Zīj*es elsewhere.

[46] For the first mention of this *Zīj*, see [Ansari 1996–97, 15].

[47] In MS 296, f. 3a–b, the author gives his family tree: his forefathers had migrated from Bukhara to India in 1657 and had been in the service of Emperor Aurangzeb initially, and later shifted to the Deccan (Hyderabad) to serve the first Niẓām.

[48] The author's title is actually *Zīj-i Niẓām ʿAlī Khānī*, as given on f. 11b

manuscripts of this work, Riyāḍī 112 and Riyāḍī 296. Both seem to be autographs. The second manuscript is more detailed. Both are in A. P. Government Oriental Manuscripts Library (Hyderabad).[49] This *Zīj* is mainly based on the *Sūryasiddhānta*, but the author mentions treatises of 'other predecessors' which he studied: namely, *Grahalāghava*, *Tithicintāmṇī*, *Laghucintāmṇī*, *Brahamatul(ya)*,[50] *Narasiṃha* and *Rāmvinod*.[51] It is interesting that the author sometimes quotes Sanskrit verses (*ślokas*) in Arabic *naskh* script with marks for vowels.[52]

2.3. *Zīj-i Sarūmanī* (1797), translated by Ṣafdar ʿAlī Khān from the *Siddhāntaśiromaṇī* of Bhāskara II, written by him in 1150 AD. Information about the translation is given in *Zīj-i Ṣafdarī* (see 2.6 below). This *Zīj* was dedicated to Arasṭū Jāh.

2.4. *Zīj-i Hindī* (1804/5), compiled by Gul Beg Munajjim ('the astronomer'), whose grandfather was the son of Mirzā Khayrullāh Khān.[53] Only two manuscripts of this *Zīj* are extant, one in Raza Library (Rampur, India), MS No. 1221, ff. 106–30; the other in the National Museum (Karachi, Pakistan), MS No. 1959-

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of MS 296, with the date of writing 1194 AH/1780 AD. *Sharḥ Zīj-i Niẓāmī* is the title under which it is indexed in the library. [Storey 1972, 100] could not identify it, since it was not available to him.

[49] This is the successor of the famous Āṣafyah Library or State Central Library, Hyderabad.

[50] MS 296, f. 5b. The first three works are by Gaṇeśa Daivajña (see section 1.1 above). *Tithicintāmaṇi* and *Laghutithicintāmaṇi* are identical; see [Sen et al. 1966, 66]. For a recent work refer to [Ikeyama & Plofker 2000]. *Brahamatul(ya)* or *Brahmasiddhāntatulya* is in fact the *Karaṇakutūhala* of Bhāskara II; see [Sen et al. 1966, entry 5, 31].

[51] These two names are mentioned on f. 2a, MS 112. Narasiṃha (ca. 1687–1747) wrote a treatise on the determination of *tithis* etc. [Sen et al. 1966, 149]. The *Rāmavinoda* of Rāma (or Rāmacandra) is based on the *Sūryasiddhānta*. It is interesting to note that 'this work was written at the instance of Mahārāja Rāmdāsa, a minister at the court of Akbar' [Sen et al. 1966, 179].

[52] For instance, in MS 296, f. 8a, a quotation from the *Sūryasiddhānta* is given.

[53] Khayrullāh son of Luṭfallāh was actually the author of *Zīj-i Muḥammad Shāhī*. He was the director at Jai Singh's observatory at Delhi.

409/2, pp. 148–76.[54] We have estimated the date of the composition by converting the 1726 'Śākha' (Śaka) mentioned (on f. 107a of the Rampur MS) in connection with the determination of the *tithi*. On f. 106b, the author declares; 'I wish to translate Makrandī, i.e., *Zīj-i Hindī*, into Persian, so that men of this field can be benefited by it and can be able to compile an Indian horoscope (*Patrah-i Hindī*).' This Makrandī may be identified with the Makaranda whose work *Makarandasāraṇī* or *Tithipatra* (written in 1478 AD) is known to us. It is an astronomical work for the compilation of calendars, based on the *Sūryasiddhānta*.[55] It contains many tables; Gul Beg's treatise comprises also 34 tables (ff. 113–30).

2.5. *Zīj-i Mīr ʿĀlamī* (1807/8) by Ṣafdar ʿAlī Khān bin Muḥammad Ḥusayn Khān bin Muḥammad Ismāʿīl Shīrāzī, extant only as a unique manuscript, MS No. Riyāḍī 301, with 162ff., in A. P. Govt. Oriental Manuscripts Library (Hyderabad). It appears to be dedicated to Mīr ʿAlam (d. 1808).[56] On f. 1b, the author states that this is a translation of *Kitāb Grahchandrikā*. Actually this is the first draft of the following *Zīj*.

2.6. *Zīj-i Ṣafdarī* (1819) by Ṣafdar ʿAlī Khān, MS Hayat 15 in Salar Jung Museum Library (Hyderabad), with 183ff. It seems to be an autograph copy. It is also a translation of *Grahchandrikā*, which may be identified with the *Grahacandrika Gaṇita* ('Calculations for Planets and Moon') by Appaya, son of Marla Perubhaṭṭa (ca. 1491).[57] Besides him he quotes also *Grahalāghva*. In connection with the fractional part of the solar year, he lists its values according to Ptolemy, Battānī, Muḥīuddīn Maghrabī, again the (author of)

[54] [Monzavi 1983, 279].

[55] Cf. [Sen et al. 1966, 135].

[56] [Storey 1972, 97] cites this information from his vol. I, part 1, p. 751. We have taken the date of composition 1807/08 from f. 2b and f. 8b, wherein the argument of the tables begins with the year 1729 'Śākha'/1807.

[57] See [Sen et al. 1966, 7]. The author declares on f. 1b that it is the most reliable of the Indian *Zīj*es.

Grahacandrika and at one point ʿAbdurāḥmān al-Ṣūfī.

2.7. *Zīj-i Sulaymān Jāhī* (1839) by Sayyid Rustam ʿAlī Raḍwī, dedicated to the ruler of Avadh, Naṣiruddīn Ḥaydar (reigned 1827–37). A unique manuscript is extant in Raza (Raḍā) Library (Rampur), old MS No. 1224 (new No. 1229),[58] with 77ff. It was copied by Muḥammad Akbar Dehlavī for Muftī Sharfuddīn Rāmpūrī. According to the author (f. 1a), he belonged to the city of Shāhjahānābād (Delhi), had been a pupil of Śrī Dhar of Benares and of Muftī Blīgh al-ʿĀlam Khān of the city of Murshidābād. He studied ancient and modern astronomical *Zīj*es and particularly *Siddhānt-charat(t)ar* (?), *Siddhānt-dinchandrī* and *Siddhāntbhāstī* etc.,[59] on which this *Zīj* is based. We may refer to sections 1.3 and 1.4 above for details about the last two sources.

4 *Concluding Remarks*

The foregoing account of the development of mathematical astronomy in Muslim India shows clearly that from the very beginning there had been substantial interaction between Arabic/Persian- and Sanskrit-knowing scholars, which in turn gave rise to a wealth of literature. We have delineated here briefly the most significant works, and further conjecture that a class of Indo-Persian sources with the general title *Risālah-i Nujum* may belong to this category of medieval Indian astronomical literature. In any case the aforementioned interaction culminated during the 18th century, when Maharaja Sawai Jai Singh established the school of translation to which we have already referred.[60] We have remarked elsewhere [Ansari 1995, 286] that

> the scientific renaissance which was gradually building up during the Mughal period and which gathered momentum through the efforts of Maharaja Sawai Jai Singh (1686–1743) could not be even sustained, due to the tremendous political turmoil and instability at the close of the 18th and beginning of the 19th centuries. The result was that the scholars and also their schools

[58] Cf. the new [*Catalogue Rampur* 1994, 346].

[59] We use here the Persian orthography.

[60] See [Sarma 1998] for details.

> could neither be patronised by the central Mughal authority in Delhi, nor by rajas, maharajas or nobles of Mughal India, hence the decline of traditional sciences in the first half of the 19th century.

However, that indigenous nascent scientific renaissance of the late medieval period was revived again by those Indian scholars who interacted with the European scholar-administrators. They responded positively to the 'New Astronomy' (*Hay'at-i Jadīd*) and acquired it quite eagerly. A number of Indo-Persian sources have been found by us in which modern European astronomy has been explained quite well.[61] This genre of writings culminated in the compilation of a treatise in Persian by a Hindu scholar, Raja Ratan Singh (d. 1851),[62] entitled *Hada'iq al-Nujūm* ('The Gardens of Astronomy'), which was lithographed at Lucknow in 1841. In this excellent and systematic treatise of 1158 pages, he mentions the astronomical work and discoveries of Copernicus, Tycho Brahe, Kepler, Galileo and Newton, and the then-recent work of Hevelius, Flamsteed, John Herschel, Cassini, Laland, to name just a few.[63] Evidently he was well aware of the works of his European contemporaries. That new development was then brought full circle when during the British period of Indian history modern astronomical observatories were established not only by the Government of India, but also by Indian monarchs,[64] which were the precursor of Indian efforts to contribute to world knowledge of astronomy and astrophysics in the last fifty years of independent India.

[Note added in proof]
To item 1, p.xxx: See [Storey, 52, n. 90]. Another manuscript of this *Zīj* is extant in Āyatullāh Mar'ashī's Library, Qum (Iran); see the article by van Dalen's in this volume.

To §3.2.2.1: Recently I have found another manuscript of *Zīj-i Muẓaffarshāhī* in the Raza Library (Rampur). It is in the Persian collec-

[61] [Ansari 2002]. In this paper we have dealt with a number of Indo-Persian sources.

[62] Ratan Singh, with *nom de plume* 'Zakhmī' ('the Wounded'), belonged to the Indo-Persian *literati* of Mughal Indian society, see [Ansari 2002, 139–141].

[63] Cf. [Ansari 2003], section 6, wherein an appreciative account of Ratan Singh's treatise is given.

[64] [Ansari 1977], revised and expanded as [Ansari 1985].

tion: *Rasā'il Hay'at*, Ms. No. 1185 b, ff. 144b–159b. The text coincides *Verbatim* with that of the manuscript of Shīrānī collection. The scribe is also anonymous as the author.

To Note 34: I have found a complete anonymous manuscript copy of the Persian translation of *Karaṇakutūhala*, in Raza Library (Rampur), Ms. No. 1185 b, ff. 118a-143b. The scribe did not date it. But from the three years mentioned in the text, viz., 801 Yazdagird/1431 AD, 803 Yazdagird /1434 AD, and 810 Yazdagird /1441 AD — the last two for the lunar and solar eclipses observed by the author in Delhi —, this translation could be dated as of 15th century, i.e., of pre-Mughal India. I intend to publish its detailed study shortly.

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