Introduction of Persian Astronomy into India

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Abstract
The Islamic astronomy including the Persian astronomy was thoroughly introduced into India from the 14th century AD or so. Firstly, the astrolabe was introduced at the time of Firûz Shâh Tughluq, and a Sanskrit work entitled Yantra-râja (1370 AD) was composed by Mahendra Sûri. At that time, some Sanskrit astronomical (or astrological) works were also translated into Persian. The astrolabe became quite popular in India, and Padmanâbha wrote the second Sanskrit work on the astrolabe in 1423 AD. During the Delhi Sultanate period and the Mughal Empire period, Islamic astronomy and Hindu Classical astronomy influenced each other. I would like to discuss the introduction of the astrolabe into India and the development of astronomy in India in this period.

Keywords: Indian astronomy, Persian astronomy, astrolabe, Firûz Shâh Tughluq, Mahendra Sûri, Padmanâbha.

Iran and India
According to modern linguistics, the origin of Iranians and that of Indo-Aryans are the same, and there are several similarities between Avestan language in ancient Iran and Vedic language in ancient India. And also, there is a community of Pârsîs (Zoroastrians) in India.

What I am going to discuss in this paper is not these ancient cultures, but the introduction of Islamic astronomy including Persian astronomy into medieval India. In medieval India (particularly Delhi Sultanate dynasties and Mughal Empire), Persian language was used as an official language, and there are several Indian historical documents in Persian. Some interesting astronomical works in Persian were also produced in India.
A brief history of Indian astronomy

The history of Indian astronomy can roughly be divided into the following periods.

(i) Indus valley civilization period.
(ii) Vedic period (ca. 1500 BC – ca. 500 BC).¹
   (ii.a) Rig-vedic period (ca. 1500 BC – ca. 1000 BC).
   (ii.b) Later Vedic period (ca. 1000 BC – ca. 500 BC).
(iii) Vedānga astronomy period.²
   (iii.a) Period of the formation of the Vedānga astronomy
         (sometimes between the 6th and 4th centuries BC).
   (iii.b) Period of the continuous use of the Vedānga astronomy
         (up to sometime between the 3rd and 5th centuries AD).³
(iv) Period of the introduction of Greek astrology and astronomy.
   (iv.a) Period of the introduction of Greek horoscopy
         (the 2nd (?) or 3rd century AD).⁴
   (iv.b) Period of the introduction of Greek mathematical astronomy
         (sometimes around the 4th century AD?).
(v) Classical Siddhānta Hindu astronomy period
    (end of the 5th century – 12th century AD).⁵
(vi) Coexistent period of the Hindu astronomy and Islamic

² See idems.
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astronomy (13/14th – 18/19th century AD).\(^1\)
(vii) Modern period (Coexistent period of the modern astronomy and traditional astronomy) (the 18/19th century onwards).\(^2\)

The Coexistent period of the Hindu astronomy and Islamic astronomy

During the previous Classical Siddhānta Hindu astronomy period (end of the 5th-12th century AD) of Indian astronomy, several astronomical treatises were written in Sanskrit.

After the establishment of Islamic dynasties in North India, the coexistent period of the Hindu astronomy and the Islamic astronomy (13/14th-18/19th century AD) began. This period is roughly divided into two subdivisions, namely the Delhi Sultanate period and the Mughal Empire period (see Appendix of this paper).

Actually, the earliest Sanskrit work which mentions a kind of the information of Islamic calendar is the *Kālacakra-tantra* (an esoteric Buddhist work, probably written in the 11th century AD), where the year of Hijra is mentioned with two years’ error. However, the calendrical system of the *Kālacakra-tantra* is basically based on the Classical Hindu astronomy, and the influence of Islamic mathematical astronomy is not found there. The *Kālacakra-tantra* is the source of the Tibetan astronomy.\(^3\) And also, there is a possibility that certain knowledge of Islamic astronomy was introduced into India by al-Bīrūnī (ca. 973-1050 AD) who studied Indian culture including

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astronomy deeply,¹ but there is no extant Indian source material which shows al-Bīrūnī’s influence at that time.

The first Sanskrit work where Islamic astronomy is explained in detail was produced during the reign of Fīrūz Shāh Tughluḵ (1351-1388 AD), the third Sultan of the Tughluḵ dynasty of India. At this time, some Sanskrit works on Hindu astronomical sciences were also translated into Persian by the order of Fīrūz Shāh. These events mark the real beginning of the coexistent period of Hindu and Islamic astronomy.

Cultural exchange during the reign of Fīrūz Shāh Tughluḵ

Introduction

The time of Fīrūz Shāh Tughluḵ was the real beginning of the cultural exchange between Muslims and Hindus in the field of astronomy. The astrolabe was introduced into India, and a Sanskrit work on the astrolabe was produced by Mahendra Sūri at the request of Fīrūz Shāh. I shall discuss this topic in the subsequent sections. And also, several Sanskrit works were translated into Persian during his reign. There are several Persian historical documents on Fīrūz Shāh’s reign (see Elliot and Dowson, III, 93–388). Among them, there is an anonymous manuscript in Persian entitled Sīrat-i Fīrūz Shāhī (1370 AD) (accession No. HL-99 Khuda Bakhsh Oriental Library, Patna) (see Muqtadir, 28–33). A facsimile of this unique manuscript was published in 1999 (Panta) with an introduction by S.H. Askari.

Persian translation of Sanskrit works

According to the Tārīkh-i Firīštah (ca. 1611 AD) of Firīštah, Fīrūz Shāh conquered Nagarkot (in present-day Himachal Pradesh), found a library of Hindu books, consisting of 1300 volumes, in a temple there, ordered one of those books, which treated of philosophy, astrology and divination, to be translated into Persian by ‘Īzz al-Dīn Khālid Khānī, and called it Dalā’il-i Fīrūz Shāhī (see Briggs, I, 263).

According to the *Muntakhab al-Tawārīkh* (1595 AD) of al-Badāyūnī (or commonly known as al-Badāawnī), it “is moderately good, neither free from beauties nor defects” (see Ranking, 332). According to the *Ṭabaḵāt-i Akbarī* (ca. 1594 AD) of Niẓām al-Dīn Aḥmad, “it is a book containing various philosophical facts both of science and practice” (see De, 249).

The manuscript *Ṣirat-i Fīrūz Shāhī* (f. 151 v.) reads as follows:

> ..."As there is the *Dalāʾil-i Fīrūz Shāh* (Book of the Reasons of Fīrūz Shāh), which was translated from Hindu’s language to Persian, on the laws of falling of rain and assembling of cloud, the laws of solar eclipses and lunar eclipses, and that what kind of reason is meant in conjunctions of stars and their transitions from zodiacal sign to sign, much of the reasons of the laws of astronomy (*nujūm*) becomes known from it."

According to some catalogues, there are some manuscripts of the *Tardjamah-i Bārāhī* (Translation of Varāha[mihira]’s work), which is a Persian translation made by ‘Abd al-‘Azīz Shams Bahā’ Nūrī at the request of Fīrūz Shāh from the *Brhatsamhita*, an encyclopaedic work on natural phenomena etc. in Sanskrit,1 of Varāhamihira (6th century AD) (For the information about Persian translation 2, see Storey, 38; Rahman, 275). It may be that this is more or less related to the *Dalāʾil-i Fīrūz Shāh*, but I have not yet seen the *Tardjamah-i Bārāhī*.

The *Ṣirat-i Fīrūz Shāhī* mentions some other related books, one of

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1. For its Sanskrit text with an English translation, see: Bhat, M. Ramakrishna (ed. and tr.), *Varāhamihira’s Brhatsamhitā*, 2 parts, Motilal Banarsidass, Delhi, 1981-82.
which (Kitāb-i Sārwālī) seems to be a Persian translation of a Sanskrit astrological work, Sārāvalī (ca. 800 AD) of Kalyāṇa-varman.

The water clock

According to the Tārīkh-i Fīrūz Shāhī of Shams Sirādī ‘Afīf, a water clock (tās-ī g’hariyālah, طاس گهریاله, where the letter “ڑ” (r) is an Urdu letter of retroflexed “r”), was placed in the Court in Fīrūzābād (in Delhi) (For its Persian original text, see Husain, 254–260; For its English summary, see Elliot and Dowson, III/338; Sarma, 2008, 125-135). The book Tārīkh-i Fīrūz Shāhī itself is written in Persian, and the word “tās” means copper bowl in Persian, but the word “g’hariyālah” is a derivative of Sanskrit word “ghaṭī” which means 1/60 of a day (i.e. 24 minutes) as well as a small water pot. Here also cultural exchange between Muslims and Hindus can be seen.

The water clock of Hindus was called “ghaṭī-yantra”, where the word “yantra” means instrument, and was a copper bowl with a small hole at its bottom. The bowl is placed on water in a large vessel, water slowly flows into the bowl through the hole at its bottom, and the bowl sinks in a ghaṭī. This type of water clock was commonly used in India, and there are several accounts of its actual use (see, for example, Ōhashi 1994, 273-279). It may be mentioned here that the description of this kind of water clock is also found in the memoir of the 1st emperor of the Mughal empire Bābur (see Beveridge, A.S., 516-517), and also in the Ā‘īn-i Akbarī, a detailed record of the reign of the 3rd emperor Akbar, of Abu’l-Fadl (see Blochmann and Jarrett, 3/17-18).

Introduction of astrolabe into India

During the reign of Fīrūz Shāh Tughluḵ, astrolabe was introduced into India from the Islamic world. This fact is recorded in Sīrat-i Fīrūz Shāhī. It (f. 152 r., see Fig.1) reads:

«استرلاب تام که آن منسوب است به استرلاب فیروز شاهی و بر بالاترین بم مقررت فیروز ای zewnętrzn تکب کرده‌اند، به اختراج و تصنیف و ارشاد و تألف خاصی حضرت سلطنت خلیل الله ملکه مرتب شده.»
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Fig. 1. Strat-i Fārūz Shāhī (f. 152 r)
“The perfect astrolabe is considered as the astrolabe of Fīrūz Shāh and has been placed on the highest roof of the minaret in Fīrūzābād was well arranged by the special innovation, writing, guidance and authorship of His Majesty of the Kingdom, may his kingdom be eternal by the protection of Allāh.”

According to its subsequent description, some scholars told the king Fīrūz Shāh about the astrolabe made in Alexandria at the time of Alexander which was a “northern astrolabe” (usturlāb-i shīmlī). Then another astrolabe which was made according to the writing of savants at the time of Alexander was brought to the King. It was “northern and southern” (shīmlī wa janābī). The King told as follows (f. 152 v, see Fig. 2):

«از اشکال و اوضاع این اسطرلاب که از تصنیف حکمتی عهد سکندر به ما رسیده است و جنوبی و شمالی است و به غور آن رسیده‌ایم و دقایق آن مرا معلوم و متوفهم گشته، می‌توانیم که از این قیاس کنیم و همان مصنوع حکمتیاران منتقل را در این صنعت منتقل با ما سازیم و اسطرلابی نام چنانکه در اسکندریه حکمتیاران به‌دست که هم شمالی باشد و هم جنوبی.»

“From the form and conditions of this astrolabe on which the writing of savants at the time of Alexander has come down to us, which is southern and northern, into which we have made investigation, and details of which have become known and understood by us, we can analogize from it, and conform us to the same product of ancient savants in this workmanship, and we may construct the perfect astrolabe as heard in Alexandria which is northern as well as southern at the same time.”

1. Actually, it must not be a historical fact that the astrolabe was made at the time of Alexander the Great, because astrolabe had not been invented at his time.
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Fig. 2. Sirat-i Firuz Shahi (f. 152 v)
The “northern astrolabe” is the usual astrolabe. The centre of its disc corresponds to the celestial North Pole, and the concentric circles of the Tropic of Cancer, the equator and the Tropic of Capricorn (which is the rim) are drawn. It is useful in the northern hemisphere. The “southern astrolabe” is the opposite, and its centre corresponds to the celestial South Pole. The “perfect astrolabe” must be the combination of these two kinds of astrolabe. We shall see in the next section that Mahendra Sūri also described a similar astrolabe called “phanḍra-yantra”.

Early Sanskrit works on astrolabe

The Yantra-rajja of Mahendra Sūri

In 1370 AD, a Sanskrit work entitled Yantra-rajja was composed by Mahendra Sūri at the request of Firūz Shāh Tughluq. It is a detailed monograph of the newly introduced astrolabe. The Sanskrit word “yantra-rajja” stands for astrolabe. The name “yantra-rajja” literally means “king of instruments”. This work is the earliest Sanskrit work on the astrolabe. This work has a commentary (ca.1377-82 AD) written by Malayendu Sūri, a disciple of Mahendra Sūri, which has been published and there exists an unpublished commentary of it (1540 AD) written by Gopirāja.

The Yantra-rajja (1.3) reads:

“Treatises on instruments have been written in several ways from their own viewpoint in their own language by Yavanas. Having churned them like oceans, I give the nectar-like essence in its entirety.”

The word “Yavana” originally meant Greek in ancient India, but it also means Western foreigner, and it must refer to Muslim here. So, Mahendra Sūri must have seen Arabic or Persian literature on the astrolabe.


2. In Raikva, op. cit.
Mahendra Sūri explained the construction of the astrolabe and related mathematical astronomy in detail.

Besides the usual “northern astrolabe” which Mahendra Sūri called “saumya-yantra” (The word “saumya” means northern.) in Sanskrit, Mahendra Sūri also described the “phanīdra-yantra”, which is a combination of “northern astrolabe” and “southern astrolabe” (yāmya-yantra). The Yantra-rāja (III.20) reads:

“Among the variations of the mixture of them (northern astrolabe and southern astrolabe), in the case of “phanīdra-yantra”, three circles (the Tropic of Capricorn, the equator and the Tropic of Cancer) should be drawn just like the northern [astrolabe]. From the last [circle] of Cancer, [whose radius is] divided by 30, the remaining two circles (the equator and the Tropic of Capricorn) should be drawn just like the southern [astrolabe].”

The rim of this instrument corresponds to the Tropic of Capricorn, and the equator and the Tropic of Cancer are drawn inside just like the usual “northern astrolabe”. The radius of the instrument (that is the radius of the outermost circle of the Tropic of Capricorn) is assumed to be 30 units. Then the innermost circle of the Tropic of Cancer is now considered to be the rim of (small) southern astrolabe whose radius is 30 (small) units. Then the equator and the Tropic of Capricorn are drawn inside just like the southern astrolabe. So, this “phanīdra-yantra” has 5 concentric circles, instead of 3 concentric circles in the usual “northern astrolabe”. This is certainly a combination of the “northern astrolabe” and the “southern astrolabe”, but it might not have been so useful. Anyway, this “phanīdra-yantra” must have been related to the “perfect astrolabe” (uşturlāb-i tām) of Fūrūz Shāh.

From the Yantra-rāja, we know that Mahendra Sūri understood the principle of the astronomy very well, and made great contribution to make it understandable to Indian scholars.

The Yantra-rāja-adhikāra of Padmanābha

The second Sanskrit work on the astrolabe was composed by Padmanābha. Padmanābha was a Hindu astronomer who wrote some
works on astronomical instruments in Sanskrit. Padmanābha was a son of Nārmada, who was also an astronomer, and Padmanābha was the father of Dāmodara, who composed two handy astronomical works, the Bhātṛ-tulya (1417 AD) and the Sūrya-tulya (1417 AD).

It is relatively well known that Padmanābha composed the Dhruva-bhramana-yantra-adhikāra (chapter two of his Yantra-ratnāvalī), whose several manuscripts are extant. Here, the “dhruva-bhramana-yantra” is the name of the instrument, and the word “adhikāra” means chapter. This is a description of a kind of nocturnal, where time can be obtained from the direction of α and β Ursae Minoris. This must be Padmanābha’s own invention. Padmanābha is also known to have composed a small work Dik-sādhana-yantra, whose single manuscript is preserved in Baroda (Vadodara).

Padmanābha also composed the Yantra-rāja-adhikāra (chapter one of his Yantra-kiranāvalī). The relationship between the Yantra-ratnāvalī and the Yantra-kiranāvalī is yet to be investigated. Only one chapter of each work is known to be extant.¹

The Yantra-rāja-adhikāra is the second extant Sanskrit work on the astrolabe. Padmanābha mentions the year “1345 Šaka” (= 1423 AD) in this work. So, this work must have been composed around this year. The astrolabe mentioned in this text is just opposite to the ordinary “northern” astrolabe, the centre of which is the celestial North Pole. The centre of Padmanābha’s astrolabe is the celestial South Pole. It means that Padmanābha’s astrolabe was the “southern astrolabe”. So, it is convenient in the southern hemisphere, but is inconvenient in the northern hemisphere including India. It may be that the astrolabe

¹ As far as I know, the Yantra-rāja-adhikāra had not been studied by modern historians of astronomy when I started my research on the history of astronomical instruments as a research scholar of Lucknow University (India) under the guidance of late Professor Kripa Shankar Shukla (1918–2007), the then retired professor of mathematics of Lucknow University (see Ōhashi, Yukio, “Prof. K.S. Shukla’s Contribution to the Study of the History of Hindu Astronomy”, Ganita Bhāratī, 17, 1995, pp. 29 – 44), in 1983. I found that two manuscripts of the Yantra-rāja-adhikāra are preserved in Lucknow University, one is in Tagore Library (central library of the university), and one is in the Department of Mathematics and Astronomy. Then I started to study this text and incorporated its partial study in my Ph.D. thesis submitted to Lucknow University. I published its complete text and an English translation in 1997 (See Ōhashi 1997).
consulted by Padmanābha was the southern type of astrolabe, which might have been one type among the several astrolabes introduced into India during the Tughluq dynasty (1320-1413 AD) or the subsequent period.

The contents of the Yantra-rāja-adhikāra consists of three sections:
1. The construction of the astrolabe, in 12 chapters;
2. The star table, in 7 chapters;
3. The use of the astrolabe, in 11 chapters.

Significance of Padmanābha’s Yantra-rāja-adhikāra is that he explained the principle of the astrolabe using Hindu traditional mathematics. This fact shows that the astrolabe was well understood by Hindu astronomers soon after its introduction.

These early Sanskrit works are the evidence that Islamic astronomy was successfully introduced into India at the time of the Tughluq dynasty and the subsequent periods.

The Yantra-prakāśa of Rāmacandra

Soon after the composition of the Yantra-rāja-adhikāra of Padmanābha, Rāmacandra, a Hindu astronomer, wrote the Yantra-prakāśa, where several astronomical instruments are described, around 1428 AD. Its manuscripts are extant in Calcutta and Pune. It consists of 6 chapters, and its first 4 chapters are devoted to the astrolabe. The description of the astrolabe in this work is largely influenced by Mahendra Sūri’s Yantra-rāja with Malayendu Sūri’s commentary (see Ōhashi 1997, 289-290). From this fact, we know that the monumental work of Mahendra Sūri produced at the request of Fīrūz Shāh Tughluq was well circulated among Hindu astronomers.

Astrolabe-makers in India

During the 16th and 17th centuries in India, several excellent astrolabes were made. The family of Allāh-Dād (fl.1567 AD) in Lahore was a well known family of astrolabe-makers.¹ Several

specimens of Indian astrolabes are extant.¹

**Conclusion**

The time of Fīrūz Shāh Tūghlūk was the beginning of the exchange of Islamic astronomy (expressed in Arabic and Persian) and Hindu astronomy (expressed in Sanskrit) in both directions. Particularly, the astrolabe was well understood by Indian scholars soon after its introduction into India.

Since then, several interesting works on astronomy were produced in India, in Persian and Sanskrit. It should be noted that there are several unpublished manuscripts (in Persian and Sanskrit) in Indian libraries, and they are waiting for future research.

My paper is only a short introduction. I hope readers of this paper are interested in this subject, and try to investigate further.

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Appendix: Development of Astronomy during Delhi Sultanate and Mughal Empire periods in North India

Firstly, it will be convenient to mention some of the names of Islamic astronomers some of whose works were well studied by medieval Indian astronomers.

The Islamic astronomy is based on the *Almagest* of Ptolemy, the most distinguished Greek astronomer of the 2nd century AD, and also accepted certain influence of Indian (Classical Hindu) astronomy. Of course, Islamic astronomers made several new contributions.

Some of the well known early Islamic astronomers (up to the 12th century or so) are: al-Khwārizmī (d. ca. 850 AD), who is famous as a mathematician; al-Farghānī (9th century), who is well known as Alfraganus in Latin; al-Battānī (ca. 858-929 AD), who is well known as Albategnius in Latin; al-Ṣūfī (903-986 AD), whose book on the constellations were well studied in India also; Ibn Yūnus (d. 1009 AD), who made observations in Cairo (Egypt), Ibn al-Haytham (ca. 965-ca. 1039 AD), who is known as Alhazen in Latin and is famous for his study of optics; al-Bīrūnī (973-ca. 1050 AD), who studied Indian culture deeply; al-Zarqālī (1029-1087 AD), who made observations in Toledo (Spain) and whose astrolabe was studied in the court of Sawai Jai Singh in India also; ʿUmar Khayyām (ca. 1048-ca. 1131 AD), who is famous as a poet and was one of the compilers of the Jalālī calendar (an Iranian solar calendar).

Islamic astronomy was transmitted to Europe during the 12th and 13th centuries or so. For medieval Indian astronomers, the works of later Islamic astronomers (in the Ilkhanid dynasty, the Timurid dynasty, etc.) were more influential.

The astronomical work (1221 AD) of Chaghmīnī, a Iranian astronomer, was well read (see Storey, 50-51).

The most important astronomer of the Ilkhanid dynasty was Nasīr al-Dīn Ṭūsī (1201-1274 AD) who made an observatory in Marāghah in 1259 AD, compiled the famous astronomical tables *Zīj-i Ilkhanī* in 1272 AD, and wrote several works (see idem, 6-7 and 52-60). Ḥuwāl-Dīn Maḥmūd Shīrāzī (1236-1311 AD), a disciple of Ṭūsī, was also a great astronomer (see idem, 64).
Mention may also be made of Ibn al-Shāṭir (1305-75 AD) at Damascus (Syria), who made a great contribution to planetary and lunar theories.

The most important astronomer of the Tīmūrid dynasty was Ulugh Beg (1393-1449 AD), who made an observatory in Samarkand, and made an influential collection of astronomical tables (usually called Zīj-i (jadīd-i) Sulṭān-i Gūrkānī or Zīj-i Ulugh Beg) in 1437 AD (see idem, 67-72). This work was well studied in India also.

There were several associates and successors of Ulugh Beg. Ghiyāth al-Dīn Jamshīd al-Kūshī (or Kūshānī), who associated with the observatory of Ulugh Beg, wrote some works on mathematics and astronomy (see idem, 72-73). Qāḍīzādahī Rūmī, who also associated with the observatory of Ulugh Beg (see idem, 8, 67), wrote a commentary on the astronomical work of Chaghmīnī. Kūshī (d. 1474/5 AD) was one of the successors of Ulugh Beg, and became a director of the observatory (see idem, 9-10, 75-77). His work was also well read in India.

The mathematical and astronomical works of Bahā’al-Dīn al-‘Āmilī (died at Iṣfahān in 1622 AD) was also well studied in India (see idem, 11-14, 86-87).

As the main theme of this paper is the introduction of the Persian astronomy into India, the following short summary is mainly limited to North India and some other Islamic areas. It may be noted here that there were some other traditions of Hindu mathematics and astronomy in South India.1

2. Delhi Sultanate period (1206-1526 AD)

Early period: Ghalamshāhīyan (Slave dynasty) (1206-90) and Khaljī dynasty (1290-1320):

(2.1) According to Storey (50), an anonymous Persian translation entitled Sirr-i maktūm translated from an astrological book of Rāzī (d.

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1209 AD) was made by order of Iltutmish (reign 1210/11-36), a Sultan of the Ghulāmshāhiyan. It may be that Islamic sciences were transmitted into India from the early stage of the Delhi Sultanate period, but exchange of sciences between Muslims and Hindus had not yet been carried on.

According to Storey (52) and S.A. Khan Gohri, the Zīj-i Nāṣirī of Maḥmūd ibn ‘Umar was produced in the mid 13th century. It seems to be the earliest collection astronomical tables in Persian produced in India.

(2.2) The time of the Tughluq dynasty (1320-1413):

The Yantra-rāja (1370 AD) of Mahendra Sūri, which is the first Sanskrit work on the astrolabe was produced at the time of Fīrūz Shāh. And also, some Sanskrit works on Hindu astronomical sciences (such as the Brhat-samhitā (6th century AD) of Varāhamihira) were translated into Persian by the order of Fīrūz Shāh (see the above main part of this paper).

It may be mentioned here that in Bahmanī Dynasty in the Deccan (outside the main territory of the Delhi Sultanate dynasties at that time), king Fīrūz Shāh Bahmanī (reign 1397–1422 AD) ordered to build an astronomical observatory on the summit of the pass near Daulatabad (in present-day Maharashtra) in 1407 AD, but it was left unfinished due to the death of Ḥakīm Ḥasan Gīlānī, the astronomer (see Briggs, II, 239).

(2.3) Later period: Sayyid dynasty (1414-51) and Lodi dynasty (1451-1526):

In the field of Hindu astronomy during the Delhi Sultanate period, one siddhānta (fundamental treatise of astronomy) in Sanskrit was produced. It is the Sundara-siddhānta (also called Siddhānta-sundara) (1503 AD) of Jñānarāja. Some interesting karanṣ (handy practical works of astronomy) in Sanskrit were also produced in this period. One is the Karanṣ-kautuka (1496 AD) of Keśava. Keśava compared the position and velocity of planets according to three schools of Hindu Classical astronomy, namely, the Brāhma school, Ārya school and Saura school, and tried to determine the best astronomical constants which agree with the actual observation. This was a great progress at that time, when the tradition of the schools was considered
to be very important. Kešava’s son Ganeša (b. 1507 AD) was also a great astronomer, and his *Graha-lāghava* (1520 AD) is a quite popular karaṇa.

Mention may be made of the cylindrical sundial in India which was first mentioned in the *Yantra-prakāśa* (1428 AD) of Rāmacandra as the “kaśā-yantra” where the word “kaśā” means whip and the word “yantra” means instrument. However, Rāmacandra’s description is very brief. The first detailed work on the cylindrical sundial in Sanskrit is the *Kaśā-yantra* (late 15th century AD) of Hema.¹ The celebrated astronomer Ganeša (b. 1507 AD) also wrote a Sanskrit work on the cylindrical sundial entitled *Pratoda-yantra* where the word “pratoda” also means whip.² Later, in the Mughal Empire period, Nityānanda mentioned the cylindrical sundial in his *Siddhānta-rāja* (1639 AD) as the “cābuka-yantra”, and Munīśvara summarized the Ganeša’s description in his *Siddhānta-sārvabhauma* (1646 AD) as the “pratoda-yantra”. Munīśvara’s description of the cylindrical sundial was separately copied sometimes, and its manuscripts are entitled *Pratoda-yantra* or *Cābuka-yantra*. Here, the Sanskrit word “cābuka” is a loanword from Persian “chābuk” which means whip. From this fact, we can suppose that some loanwords from Persian were popularly used in Sanskrit at that time. It is not known whether the Indian cylindrical sundial was influenced by similar instruments in the Islamic world or was invented independently in India.

3. *Mughal Empire period* (1526 - 1858 AD)
   (3.1) From the time of Bābur to the time of Aurangzeb (1526-1707):
   (3.1.1) The time around the reign of Bābur (1526-30): The Mughal Empire was founded by Bābur. Bābur’s memoire *Bābur-nāma* (originally written in Chagatai (Turkic) language) is an

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². For its Sanskrit text with an English translation, see Ōhashi, op. cit.
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important source material of his activity.¹ Bābur mentioned the astronomical observatory of Ulugh Beg (1393-1449 AD) in Samarkand, where he visited in 1498 AD, and noted some other observatories known to him (see Beveridge, A.S., 79).

(3.1.2) The time around the reign of Humayun (1530-40 and 1555-56):

Muṣṭiḥ al-Dīn Lārī Anšārī (d. 1571 at Constantinople) wrote a Persian commentary on the Risālah dar Hay’at of Ḵūshā (d. 1474/5 AD), and dedicated it to Humāyūn (see Storey, 77; Rahman, 336).

Humāyūn was interested in astronomical instruments, and it seems that the family of Allāhdād (fl. 1567 AD) in Lahore, a well known family of astrolabe-makers, have commenced under the patronage of Humāyūn.

(3.1.3) The time around the reign of Akbar (1556-1605):

According to S.A. Khan Ghorī, Mullā Chānd, a friend of Humāyūn and a court astronomer of Akbar, made a simplified version of Ulugh Beg’s table. The work of Mullā Chānd is entitled Ṭashīl-i Zīj-i Ulugh Begī.

At the time of Akbar, the Pārasī-prakāśa, a Persian grammar and Persian grammar in Sanskrit, was composed by Bhārī Kṛṣṇa-dāsa Miśra.² From this fact, we know that some people seriously tried to exchange cultures including astronomy between Muslims and Hindus.

At the instance of Akbar, the Līlāvatī (1150 AD), a famous arithmetical work in Sanskrit,³ of Bhāskara (b. 1114 AD) was translated into Persian by Fayḍī, a court poet of Akbar and an elder brother of Abufaḍl (see Storey, 4-5).

Abufaḍl (1551-1602 AD), a consultant of Akbar, wrote two very important records of the reign of Akbar and related topics, namely the Akbar-nāmah⁴ and the ‘Ā’in-i Akbarī. Valuable information about

1. For its English translation, see Beveridge, A. S.
2. For its Sanskrit text, see Bhāṭṭācārya Viśhūṭībhūṣaṇa (ed.): Pārasī-prakāśa, Sarasvatī Bhavana Granthamāla, vol. 95, Varanaseya Sanskrit Vishvavidyalaya, Varanasi, 1965.
science and technology at that time is found in these works.

In 1584 AD, Akbar established a new solar calendar “Tārīkh-i Ilāhī” (Divine), which was based on the Persian solar calendar. The main compiler of this calendar was Fathullāh Shīrāzī (d. 1589 AD), who joined the court of Akbar in 1583 AD, and was a great scientist and engineer (see Beveridge H., II, 15-18; III, 644-645; Blochmann and Jarrett, II, 1-31; Alvi & Rahman, 17-23).

The Āʿn-i Akbarī (Mode of governing of Akbar) has some valuable descriptions of Islamic and Hindu astronomies and related topics, such as a section of eras and astronomers (see Blochmann and Jarrett, 2/1-31), a section of cosmology and astronomy (see Blochmann and Jarrett III, 11-28), a section of the description of the earth (see idem, III, 29-125), etc.

In the field of Hindu astronomy, Raṅganātha (son of Ballāla)² wrote a commentary (1603 AD) on the Śūrya-siddhānta (ca. 10ᵗʰ-11ᵗʰ century AD), one of the most popular treatises of astrology in Sanskrit. This is the most popular commentary on the Śūrya-siddhānta, and an English translation of the Śūrya-siddhānta which is probably the most popular book on Hindu traditional astronomy in English is also based on this version.³

(3.1.4) The time around the reign of Jahāngīr (reign 1605-27):
Jahāngīr was interested in natural history, and there are several interesting descriptions of animals and plants, and also astronomical phenomena in his memoir.⁴

(3.1.5) The time around the reign of Shāh Jahan (1628-58):

1. For its English translation, see Blochmann, H. and H.S. Jarrett (trs.) The Āʿn-i Akbarī, 3 vols, (originally published in 1873-1894; vol.1 was translated by Blochmann, and vols. 2 and 3 were translated by Jarrett), Second Edition, Royal Asiatic Society, Calcutta, 1927(actually 1939)-1949; reprinted: Oriental Books Reprint Corporation, New Delhi, 1977-78.

2. As there were two astronomers named “Raṅganātha” in this period, they are distinguished by their respective father’s name.


Some new siddhāntas in Sanskrit were composed during this period. Nityānanda wrote the Siddhānta-sindhu (1628 AD), and the Siddhānta-rāja (1639 AD) in Sanskrit under the reign of Shāh Jahān.

At the same time, Fard al-Dīn Masʿūd ibn Ibrāhīm Dihlawī (d. 1629 AD), a court astronomer of Shāh Jahān, composed the Zīj-i Shāh Jahānī (1629 AD) in Persian (see Storey, 89; Rahman, 306-307).

It may be interesting to note that there were two rival Hindu families of astronomers at that time as follows:

Munjīvara (b. 1603 AD) (son of Raṅganātha (son of Ballāla), see above) wrote the Siddhānta-sārvabhauma in 1646 AD. This work basically follows the Sūrya-siddhānta. He was criticized by Raṅganātha (son of Nṛsiṃha) (see below). Munjīvara also wrote some other astronomical and mathematical works, such as a commentary on the Siddhānta-śīromaṇī (1150 AD) of Bhāskara (b. 1114 AD).

Raṅganātha (son of Nṛsiṃha) wrote some astronomical works, and criticized Munjīvara, and was then criticized by Gadādhara (nephew of Raṅganātha (son of Ballāla), and cousin of Munjīvara). Raṅganātha (son of Nṛsiṃha)’s brothers Divākara (b.1606 AD) and Kamalākara (see below) were also astronomers.

Kamalākara (son of Nṛsiṃha) wrote the Siddhānta-tattva-viveka in 1658 AD. This work basically follows the Sūrya-siddhānta. He also wrote a commentary on the Sūrya-siddhānta.

In the field of Persian literature, ‘Aṭā’ullāh “Rushīd” (or “Rashīd”), the eldest son of Ustād Aḥmad (see Storey, 14-15) (architect of Tāj Maḥal made by Shāh Jahān)¹, translated the Bīja-ganita (1150 AD), a famous algebraic work of Bhāskara (b. 1114 AD) in Sanskrit² into Persian in 1634/35 AD, and dedicated it to the Mughal emperor Shāh Jahān (see Storey, 5, 15-16; Rahman, 391-392). His younger brother Luṭfullāh “Muhandis” was also an astronomer and mathematician (see below).

(3.1.6) The time around the reign of Aurangzeb (1658-1707):

Luṭfullāh “Muhandis”, a son of Ustād Aḥmad (architect of Tāj Maḥal), wrote the Tadżamah-i Kitāb-i Šuwār-i Kawākib (1640 AD), a

¹. For he and his sons, see Chaghtai, M. Abdullah, “A Family of Great Mughal Architects”, Islamic Culture, 11(2), 1937, pp. 200 – 209.
². For its English translation, see Colebrooke, op. cit.
Persian translation of the book on constellations of al-Ṣūfī, and the Takwīm-i Lutfī (1673/4 AD) on almanac, and also some other mathematical works such as an abridged Persian translation (1681 AD) of al-ʿĀmilī’s mathematical work (see Storey, 11-12, 16, 41-42, 92; Rahman, 324-325, 404-405). His sons Imām al-Dīn Ḥusayn and Khayrullāh were also astronomers and mathematicians (see below).

ʿĪṣmatullāh (d. 1732 AD) wrote an Arabic commentary (ca. 1670 AD) on al-Ṭūsī’s Arabic version (1265 or 1271 AD) of Ptolemy’s Almagest, and a commentary (ca. 1675 AD) on al-ʿĀmilī’s astronomical work (see Storey, 86-87; Rahman, 316-317).

(3.2) Later Mughal Period (1707-1858):

(3.2.1) Around the 18th century:

After the death of the emperor Aurangzeb, the Mughal Empire more or less declined, but astronomical activities did not decline. The most eminent figure of this period is Savāṉ Jaya Simha (or Sawai Jai Singh in usual English spelling) (1699-1743 AD), Mahārāja of Amber (later shifted to Jaipur).¹

Savāṉ Jaya Simha constructed five traditional astronomical observatories, among which four still exist, in the first half of the 18th century.² Some astronomical works in Sanskrit and Persian were composed at his court. Among them, one of the most important works is the Zūj-i javād-i Muḥammad Shāhī (1728 AD) in Persian³ (see Storey, 93-94; Rahman, 348-350; Sharma, 234-253). And also, at his court, Jagannātha translated al-Ṭūsī’s Arabic version (1265 or 1271 AD) of Ptolemy’s Almagest into Sanskrit as the Samrāṭ-siddhānta⁴, and al-Ṭūsī’s Arabic version (1248 AD) of Euclid’s Elements into Sanskrit as the Rekhā-gaṇita.

¹. “Mahārāja” is a kind of local king, and Savāṉ Jaya Simha constructed a new city, which was later named “Jaya-pura” (or Jaipur in usual English spelling), near his original place Amber.


Jagannātha also composed his own *Siddhānta-kaustubha*. Its enlarged version is known as *Siddhānta-samrāṭ*, which is different from the translation of the *Almagest*. In the *Siddhānta-samrāṭ*, a description of al-Zarkār’s astrolabe is also included (see Sarma, 223–239).

By this time, Nayanassukha-upādhyāya (fl. 1729 AD), who also associated with the court of Savaī Jaya Sirīha (see Sharma, 274–275), translated the *Būst Bāb dar ʿUsūrlāb*, a famous work on the astrolabe composed by al-Ṭūsī in Persian, into Sanskrit as the *Yantra-rāja-vicāra-vimśādhyāyī*. He also translated the Arabic version of the *Spheres* of Theodosius (ca. 1st century BC) as the *Ukarā* into Sanskrit, and a part of al-Birjandi’s commentary on the *Tadhkira* of al-Ṭūsī into Sanskrit.

By this time, sons of Lutfullāh “Muhāndis” were also active as follows:

‘Imām al-Dīn Ḥusayn, the eldest son, composed several works on astronomy and mathematics including Arabic glosses (ca.1725 AD) on Qāḍīzādah-i Rūmī’s commentary on the astronomical work (1221 AD) of Chaghmīnī, and a commentary (ca.1725 AD) on the astronomical work of al-ʿĀmilī (see Rahman, 316). ‘Imām al-Dīn Ḥusayn wrote a biographical work *Tadhkira-i Bāghistān*, which contains valuable information about astronomy and astronomers.

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2. For its Sanskrit text, see Caturveda, Murālīdharā (ed.), *Siddhānta-samrāṭ*, Sāgarikā-samīti, Sāgara-vaśvavidyālaya, Sagar, 1976.


Khayrullāh, the second son, according to Rahman (285), was appointed to be a director of the observatory at Delhi, but, according to Sharma, it is doubtful. Khayrullāh wrote some works on astronomy and mathematics including a Persian translation (1747 AD) of al-Ṭūsī’s Arabic version of Ptolemy’s *Almagest* and a Persian translation (1731/2 AD) of al-Ṭūsī’s Arabic version of Euclid’s *Elements* (see Storey 1, 37, 95; Rahman, 285, 386).

According to Rahman (320), Khwādżah Bahādur Ḩusayn Khān, who served Aurangzeb and later went to Deccan with Ẓīj-i Ḵoẕām al-Mulk, wrote the *Ẓīj-i Niẓāmī* in Hyderabad, where the method of finding dates from various calendars including the date of accession of Āṣaf Jāh II (reign 1762-1803 AD) is mentioned (see Storey, 100; Rahman, 320).

It may be mentioned here that there is an anonymous Sanskrit work on Islamic astronomy composed in 1764 AD, the *Hayata*-grantha*1*. The word “hayata” is of course Sanskrit transliteration of “hai’at” or astronomy in Persian.

There is also a Persian treatise entitled *Dar ‘ithbāt-I hay’at-I dijadičd* (on the proof of the modern astronomy) composed in India between 1770 and 1772 AD by an Iranian scholar Abū Ṭālib ibn Ḩasan Ǧuṣaynī Ṣafavī. Its manuscript exists in Gharb Library (Hamadan, Iran), and has been published.*2*

(3.2.2) Around the 19th century:

There is a voluminous work entitled *Jāmī’-i Bahādur Khānī* (1833 AD) (published in 1835 AD) of Ghulām Ḩusain (1790-1862 AD)*3*,

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2. Ṣafavī, Abū Ṭālib ibn Ḩassan Ḩusaynī, “Dar ‘ithbāt-i hay’at dijadičd” edited by Ḩusain Maṣūmī Hamadānī, *Ma‘ārif*, vol. 1, no. 2, Iran University Press, Tehran, pp. 117–185. I am grateful to Prof. Mohammad Bagheri who provided me with this information, and kindly sent its copy to me. There is another manuscript of it in Rampur Raza Library (See *Catalogue of Persian Manuscripts of Rampur Raza Library*, 1, 347).

which is probably the last comprehensive Persian traditional mathematical and astronomical work written in India (see Storey, 19-20, 99; Rahman, 387). He also compiled the Zij-i Bahādur Khānī (1838 AD) (published in 1855 AD), an astronomical table (see Storey, 99; Rahman, 309). According to Bagheri (5), this Zij was the main source for the traditional calendar makers of Iran for a certain period.

There is also an interesting Persian work on modern astronomy written in India, the Ĥadāʾiq al-Nujām (1837 AD)¹ (published in 1837, 1841 and 1843 AD) of Rājah Ratan Sing’h (1782-1851 AD) (see Storey, 99-100; Rahman, 350).

From the above brief sketch, it is clear that both of the Sanskrit literature and Indo-Persian literature on astronomy are very important, and much more research work is needed.

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