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Persian Astronomy in Sanskrit
A Comparative Study of Mullā Farīd's Zīj-i Shāh Jahānī and its Sanskrit Translation in Nityānanda's Siddhāntasindhu

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Article abstract

Starting from the late medieval period of Indian history, Islamicate and Sanskrit astral sciences exchanged ideas in complex discourses shaped by the power struggles of language, culture, and identity. The practice of translation played a vital role in transporting science across the physical and mental realms of an ever-changing society. The present study begins by looking at the culture of translating astronomy in late-medieval and early-modern India. This provides the historical context to then examine the language with which Nityānanda, a seventeenth-century Hindu astronomer at the Mughal court of Emperor Shāh Jahān, translated into Sanskrit the Persian astronomical text of his Muslim colleague Mullā Farīd. Nityānanda's work is an example of how secular innovation and sacred tradition expressed themselves in Sanskrit astral sciences. This article includes a comparative description of the contents in the second discourse of Mullā Farīd's Zīj-i Shāh Jahānī (c. 1629/30) and the second part of Nityānanda's Siddhantasindhu (c. early 1630s), along with a critical examination of the sixth chapter from both these works. The chapter-titles and the contents of the sixth chapter in Persian and Sanskrit are edited and translated into English for the very first time. The focus of this study is to highlight the linguistic (syntactic, semantic, and communicative) aspects in Nityānanda's Sanskrit translation of Mullā Farīd's Persian text. The mathematics of the chapter is discussed in a forthcoming publication. An indexed glossary of technical terms from the edited Persian and Sanskrit text is appended at the end of the work.

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1 INTRODUCTION

Over the course of the history of Sanskrit mathematical astronomy, foreign ideas have evoked a full range of emotions that extend from affinity to apathy, going all the way to antipathy. These reactions are a reflection of the intellectual diversity of Indian astral sciences (*jyotiḥśāstra*). Historical actors may have chosen to accept, reject, or ignore foreign ideas based on their scientific convictions; however, those choices could only be expressed under the aegis of the political and sociocultural institutions of the times.

With the turn of the seventeenth century of the common era, Sanskrit astronomers/astrologers (*jyotiṣas*, *jyotiṣikas*, or more colloquially *jyotiṣīs*) and their Persianate counterparts (*munajjims*) were working under the common patronage of the imperial court of Mughal India.[1] At the court of Emperor Shāh Jahān (r. 1628–58), we find the Gauḍa Brahmin Paṇḍita Nityānanda Miśra (fl. 1630/50) working alongside Mullā Farīd al-Dīn Masᶜūd b. Ḥāfiẓ Ibrāhīm Dihlavī (d. c. 1629/32; henceforth identified as Mullā Farīd) to translate into Sanskrit the latter's Persian *zīj* (a handbook of astronomical tables) the *Zīj-i Shāh Jahānī* (c. 1629/30). Nityānanda's Sanskrit translation, the *Siddhāntasindhu* (c. early 1630), was his first attempt at explaining Islamicate computations and astronomical tables to his fellow Sanskrit *jyotiṣīs*.[2]

By the end of the decade, he included several of these Islamicate ideas in his canonical treatise the *Sarvasiddhāntarāja* 'The King of all Siddhāntas' (1639). The *Sarvasiddhāntarāja* is composed in the style of a traditional Sanskrit *siddhānta* (a canonical treatise in astronomy) and has a tripartite structure: the *gaṇitādhyāya* 'chapter on computations', the *golādhyāya* 'chapter on spheres', and the *yantrādhyāya* 'chapter on instruments'.[3] In contrast, the *Siddhāntasindhu* mimics the structure and content of the Persian *Zīj-i Shāh Jahānī* quite intimately.

1 The *Gūrkāni Ālam* or the Mughal Empire was an early-modern Muslim empire in South Asia led by monarchs of the Timurid dynasty. From 1526 to 1857 CE, the successors of Ẓahīr al-Dīn Muhammad Bābur, the first Mughal Emperor, extended their dominion over large swathes of the Indian subcontinent, and in doing so, helped create a highly complex cosmopolitan society extending beyond its imperial borders. I refer to this cultural sphere of influence of the Mughal rule as Mughal India.

2 I use the word Islamicate (instead of Islamic) to indicate the cultural outputs (e.g., artistic, literary, or scientific works) of Muslim societies educated in the Arabic and Persian language traditions but not directly connected to the Islamic faith or any particular geographic region (see recent discussions on Islamicate Secularities in Dressler et al. 2019).

3 Misra (2016: Sections 1.1 and 1.2 on pp. 1–20) offers a fuller discussion on Sanskrit astronomy in early-modern India, in particular, the contribution of Nityānanda and his *Sarvasiddhāntarāja*. Also, contemporary studies like Pingree (2003*b*), Montelle, Ramasubramanian, et al. (2016), and Montelle and Ramasubramanian (2018) discuss Islamicate influences in the mathematical computations described in the *Sarvasiddhāntarāja*.

In this study, I compare the general structure of the *Zīj-i Shāh Jahānī* and the *Siddhāntasindhu* in parallel, and subsequently focus on a chapter from each of these works that discusses the same topic, viz. the declination of a celestial object. My aim is to highlight the semantic and communicative aspects in Nityānanda's Sanskrit translation of Mullā Farīd's Persian text. I defer all remarks on the mathematics in Nityānanda's text to Misra (forthcoming).[4] Instead, I first begin by discussing the practice of translating Sanskrit, Arabic, or Persian astronomical texts during the late-medieval and early-modern periods of Indian history. This overview, built from separate studies on the history, philosophy, and language of astral sciences in India, gives us the context to situate Nityānanda's works in the world of seventeenth-century Mughal India.[5] His writings can then be seen as an ongoing dialogue between different scientific traditions in a changing society, instead of simply being judged as a 'failure' and an 'elaborate apology for using Muslim astronomy' (Pingree 2003*b*: 270).

1.1 TRANSLATING THE ASTRAL SCIENCES IN PERSIANATE INDIA[6]

1.1.1 Before the Mughal court

SANSKRIT TEXTS ON ASTRONOMICAL INSTRUMENTS (*yantra*) written in the late fourteenth century offer some of the earliest extant evidence of a relationship between Islamicate and Sanskrit mathematical astronomy.[7] S. R. Sarma (1999) provides an excellent overview of Sanskrit texts on astrolabes, many of which include lengthy discussion on Islamicate mathematical astronomy. Mahendra Sūri's *Yantrarāja* (1370), along with his student Malayendu Sūri's commentary on it (in 1382), is the earliest and most recognised of such works (Plofker 2000).

4 Appendix A includes the mathematical expressions (using modern notations) of the three algorithms to compute the true declination of a celestial object commonly attested in Mullā Farīd's *Zīj-i Shāh Jahānī* Discourse II.6 and Nityānanda's *Siddhāntasindhu*, Part II.6.

5 For example, see Pingree (1978), Ansari (1995), Pingree (1996), Ansari (2005), and Ôhashi (2008) for historical accounts of Sanskrit and Persian astronomy in India; Choudhuri (2009) and Minkowski (2014) for surveys of Sanskritic (Hindu and Jain) scholars under Muslim patronage; and Minkowski (2002; 2004), Truschke (2016), and Nair (2020) for linguistic and philosophical reforms affecting Sanskrit *jyotiḥśāstra* in early-modern India.

6 The word Persianate refers to a sociocultural association with the Persian language (Fārsī) extending beyond the ethnic identity and geographical boundaries of Persia (much like the word Islamicate distinguishes itself from Islamic, see footnote 2). I use the expression 'Persianate India' to refer the geographical regions of late-medieval and early-modern India where Persian culture (expressed in its art, language, literature, and science) directly influenced society (see Eaton 2019).

7 Sanskrit *tājika* texts are Indian adaptations of Islamicate astrology that were composed from the thirteenth century CE. Pingree (1997) provides a historical summary of the *tājika* literature in Sanskrit, while Gansten (2019) studies the transmission of Perso-Arabic *tāzīg*-astrology in the *Karmaprakāśa* (c. 1274) of Samarasiṃha, the earliest preserved Sanskrit *tājika* work.

Mahendra Sūri was a Jain monk-astronomer at the court of Sulṭān Fīrūz Shāh Ṭughlāq (r. 1351–88), a Turko-Indian ruler of the pre-Mughal Sultanate of Delhi, and is thought to have worked in close association with 'unnamed Muslim astronomers at Fīrūz's court' (S. R. Sarma 1999: 148). S. R. Sarma qualifies him as a 'mediator between the Islamic and Sanskritic tradition of learning' (p. 149). This is perhaps justly so, as three hundred years later, the language and structure of Mahendra Sūri's *Yantrarāja* continues to echo in the works of several seventeenth-century authors. The *Yantraśiromaṇi* (c. 1612/15) of Viśrāma of Jambūsara, the *Vāsanāvārttika* (1621) of Nṛsiṃha Daivajña of Kāśī, and the *Sarvasiddhāntarāja* (1639) of Nityānanda are three such examples.[8]

1.1.2 *At the Mughal court*

During the Mughal rule of India, the practice of translation became an administrative activity under the patronage of the Mughal emperors. Various kinds of literary, historical, religious and scientific texts in Sanskrit were chosen to be translated into Persian. As Alam and Subrahmanyam (2011) and Truschke (2016) have astutely observed, these translations served, more than anything else, to help the Mughal crown conceive and consolidate its self-identity as a ruling establishment harmonious with locally existing notions of kingship.[9] For a small group of professionals, however, these translation projects offered more immediate opportunities for employment at the Mughal court and with it, a chance for social recognition.

We learn from the sixteenth-century Mughal historian ʿAbd al-Qādir b. Mulūk Shāh Badāʾūnī that Emperor Akbar (r. 1556–1605) established a scriptorium (*maktabkhāna*) where secretaries, scholars, and scribes worked collaboratively to produce Persian editions of Sanskrit texts.[10] According to Badāʾūnī,

8 Mahendra Sūri's *Yantrarāja*, along with Viśrāma's *Yantraśiromaṇi* is edited by Raikva (1936). Nṛsiṃha Daivajña's *Vāsanāvārttika*, a commentary on Bhāskara II's *Siddhāntaśiromaṇi* (1150), is edited by Chaturvedi (1981). There are no known editions or translations of Nityānanda's *Sarvasiddhāntarāja* in its entirety. S. R. Sarma (1999: 149) describes how the structure of the *yantrādhyāya* 'chapter on instruments' from the *Sarvasiddhāntarāja* mimics that of Mahendra Sūri's *Yantrarāja* on the basis of MS 264 from the Asiatic Society of Bombay.

9 Haider (2011) offers an excellent study on the role of language and translations in the context of intercultural communication and Mughal state-building. Israel (2018) builds on this to examine the complex ways in which translation processes and political discourses are mobilised to shape cultural and national identities. In talking about the scientific activities at the Mughal court of Emperor Humāyūn (r. 1530–56), Anooshahr (2017) notes that 'the court's network of patronage reflected the cosmopolitan (and cosmocratic) ambitions of the emperor, extending to intellectuals from Shiraz, Herat, Istanbul, Gwalior and Samarqand. The changes continued and intensified as the remaining decades of the century unfolded' (p. 315).

10 See Badāʾūnī's *Muntakhab al-Tawārīkh*, Lees and Ali (1865: Vol. II, p. 344) for the

Sanskrit interpreters (*muʿabbirān*) and Persian translators (*mutarjimān*) worked separately at different stages of the translation process.[11] Starting with a vernacular paraphrasing of the Sanskrit text by Hindu/Jain scholars (*paṇḍitas* or *śāstrins*), perhaps in a colloquial dialect of Hindavī, Khaṛībolī, or Brajabhāṣā,[12] a preliminary Persian translation was prepared by Muslim clerks/secretaries (*muḥarrirs*). This was then refined by more accomplished Persian scholars (*ustādhs* or *mutamarrises*) into its final form over several revisions (Hodīvālā 1939: 564–566).

It is reasonable to think that this process also occurred in reverse as Persian texts were translated into Sanskrit. In his *Āʾin-i Akbarī*, Akbar's chronicler Abu ʾl-Faḍl ʿAllāmī mentions at least one instance where a Persian astronomical text was translated into Sanskrit: the *Zīj-i Jadīd-i Mīrzāʿī* (alias *Zīj-i Ulugh Beg*) was translated into Sanskrit (*Jīca Ulugbegī*) under the superintendence of Amīr Fatḥallāh of Shīrāz with the assistance of Kishan Joshī, Gaṅgādhar, and Mahesh Mahānand (Phillott 1977: 110).[13]

In Shāh Jahān's reign, beginning in 1628, we find a Persian translation *Tarjuma-yi Bījganit* (c. 1634/35) of Bhāskara II's *Bījagaṇita*, a celebrated twelfth-century Sanskrit treatise on Algebra, written by the Mughal architect ʿAṭaʾ Allāh Rushdī and dedicated to Emperor Shāh Jahān (Ansari 2019: 384–386). This is also around the same time when Nityānanda translated Mullā Farīd's Persian *Zīj-i Shāh Jahānī* into his Sanskrit *Siddhāntasindhu*. Although there are no intermediaries (interpreters/translators) that are explicitly named in either of these works, there are historical precedents from the literary traditions, particularly those patronised by the Muslim nobility of early-modern India, to suppose the presence of bilingual interlocutors.[14]

Persian text; its English translation can be found in Lowe (1884: Vol. II, p. 356). Also see Rizvi (1975: Chapter 6, pp. 203–222) for a descriptive list of the Sanskrit works translated at Akbar's *maktabkhāna*, including Abu ʾl-Fayḍ Fayḍī's Persian translation *Tarjuma-yi Līlāwatī* of Bhāskara II's *Līlāvatī* (c. mid-twelfth century CE) from 1587.

11 *Muntakhab al-Tawārīkh*: Persian text in Lees and Ali (1865: Vol II, pp. 320–321) and its English translation in Lowe (1884: Vol. II, pp. 329–330).

12 As Alam (1998) observes, '[h]indavī was recognized as a semi-official language by the Sūr Sultāns (1540–55) and their chancellery rescripts bore transcriptions in the Devanāgarī script of the Persian contents. The practice is said to have been introduced by the Lodīs (1451–1526)' (p. 319). see Behl (2012) for a study of the Hindavī literary traditions in pre-Mughal India; Bangha (2010) for the emergence of Khaṛībolī literature in Northern India; and Busch (2010) for poetry in Brajabhāṣā at the Mughal courts.

13 H. Blochmann translated the first two books of the *Āʾin-i Akbarī* into English in 1873 (published by the Asiatic Society of Bengal). Phillott edited and revised the second edition in 1927, which was then reprinted in 1977. As S. R. Sarma (2000: footnote 20 on p. 367) points out, Blochmann's statement on translating the *Zīj-i Ulugh Beg* by a consortium of Sanskrit scholars is indeed 'hopelessly garbled' in his English translation in all three editions.

14 For instance, based on her study of the vernacular literary culture of early-modern North India, Orsini (2012) remarks that 'it is better to understand the literary culture

Beyond these literary traditions, we learn from Alam (1998: 327–328) that by the middle of the seventeenth century, most administrative positions in the Mughal chancellery were occupied by Persian-speaking Hindu *munshis*, many of whom made significant contributions to Persian literature.[15] The power and prestige associated with being literate in Persian extended beyond the circles of Hindu imperial administrators—including, of course, Hindu nobility like the Rajput kings—and even reached low-ranking officials in smaller towns and villages. By the time of Shāh Jahān's reign, Persian classics like *Akhlāq-i Nāsirī* of Naṣīr al-Dīn al-Ṭūsī or *Masnavī-yi Maᶜnavī* of Jalāl al-Dīn Rūmī became regular reading material even among the less-prominent Hindus associated with the Mughal state (Alam 1998: 328).

Alam's observations allow us to see how Persian became a tool of socioeconomic mobility for the professional classes in seventeenth-century Mughal India. The Sanskrit *jyotiṣīs* (and perhaps, even the Muslim *munajjims*) served as astrologers for various high-ranking Hindus in the Mughal realm.[16] These Hindus, as Truschke (2016) describes them, 'joined the Mughal administration and became absorbed into Persian-speaking communities' (p. 8). Essentially, they were now a part of the Mughal Persianate elite. As their consultant astrologer, the ability to be reasonably bilingual (fluent in vernacular Hindi and conversant in Persian) would have been a competitive advantage and social distinction for any Hindu *jyotiṣī* schooled in Sanskrit.

From the seventeenth century, the linguistic hegemony of Persian that served the political ambitions of the Mughal crown was met with the rising popularity (and patronage) of vernacular literature among the Persianate elite, (e.g., see Busch 2011: chapters 3–4). The prominence of Hindavī/Brajabhāṣā literature, coupled with a politico-cultural shift towards the vernaculars (in other words,

in fifteenth-century north-India as a multilingual and multilocation literary culture—with a trend towards Persian-Hindavi bilinguality in the domains of politics and literature of the various regional Sultans and in the Sufi religious and literary practices' (pp. 238–239).

15 Many Hindu *munshis* at the Mughal courts wrote epistolary prose (*inshā*) and composed poetry in Persian. The story of Chandar Bhān Brahman (d. c. 1666–70), a Brahmin *munshi* who lived through the reign of four Mughal emperors, is a fascinating tale of how a Hindu secretary came to be regarded as one of the great Persian prose stylists and poets of his era. Kinra (2015) offers a particularly compelling account of the literary, social, and political worlds of Shāh Jahān's Mughal India through the life and works of Chandar Bhān Brahman.

16 For example, Mālajit Vedāṅgarāya (fl. 1643, also known as Śrīmālajī) was a Hindu *jyotiṣī* at Shāh Jahān's court. His admittance to the imperial court was presumably mediated by his immediate patron Rāja Giridhara Dāsa, the Rajput King of Ajmer, to whom, Śrīmālajī dedicated his *Giridharānanda* 'The joy of Giridhara' (Minkowski 2014: 121–122). As Minkowski remarks, 'the presence of a *jyotiṣa* at a particular court appears in some cases to have been rather notional. The Banarsī paṇḍits, in particular, received gifts, honors, or patronage simultaneously from several courts, large and small' (p. 116).

treating vernacular texts as sources of cultural history instead of those written in Sanskrit) led to renewed ways in which Persian writers engaged with the vernacular cultures.[17]

Sanskrit poets also learned to adapt to this shift towards the vernaculars. Many scholars maintain that the literary eminence of Sanskrit at the Mughal court began to wane in the reign of Shāh Jahān (e.g., Pollock 2001; Truschke 2016).[18] The accounts of two Hindi-speaking Brahmin poets at Shāh Jahān's court, Kavīndrācārya Sarasvatī Vidyānidhāna (fl. c. 1600/75) and Jagannātha Paṇḍitarāja (fl. c. 1620/60), describe how two eminent Sanskrit scholars ingratiated themselves with the emperor and his retinue by composing panegyrics in Brajabhāṣā and singing Hindustānī *dhrupad* songs at the Mughal court (Truschke 2016: 50–53).

For lesser-known Sanskrit *jyotiṣīs* like Nityānanda, however, one can imagine that the changing tides of patronage and the competition to find patrons, would have presented very different challenges to those faced by courtly bards singing encomiums. Nityānanda's name appears in the annals of Sanskrit *jyotiḥśāstra* as the author of *Siddhāntasindhu*—a Sanskrit translation of a Persian original sponsored by Āṣaf Khān, the prime minister (*vazīr-i āᶜẓam*) of Shāh Jahān and a highly influential Mughal elite. It is, therefore, not inconceivable that Nityānanda might have had some basic level of Persian literacy to begin with, or at the very least, developed it through his interactions with Mullā Farīd (in vernacular Hindi) over the course of his commission. The grammatical affinity between Mullā Farīd's Persian passages and their Sanskrit translation in Nityānanda's *Siddhāntasindhu* supports this belief to a certain extent (more on this in § 2.3.2).

Sanskrit manuals on learning Persian Between the fourteenth and eighteenth centuries, several Sanskrit compendiums were authored to teach Persian to Sanskrit-speaking audiences (e.g., see S. R. Sarma 1995; Truschke 2012). Typically, these

17 For instance, Mīrzā Khān b. Fakhr al-Dīn Muḥammad wrote his encyclopedic Persian digest *Tuḥfat al-Hind* (c. 1674/75) 'Gift from India' on the 'current Indian sciences' (*ᶜulūm-i mutadāwila-yi hindiya*) during the reign of Mughal Emperor Awrangzīb ᶜĀlamgīr (r. 1658–1707). His book includes discussions on various topics of ordinary and academic interests peculiar to the people of who spoke *Braj Bhākhā* (Brajabhāṣā). See Ziauddin (1935) for an English translation of Mirzā Khān's elaborate exposition of the grammar of *Braj Bhākhā*; and more generally, see Alam (1998: 342–348) for a historical summary of the relationship between Persian and Hindavī at the Mughal courts.

18 In contrast, Sanskrit poetry (*kāvya*) composed outside the central Mughal court played a critical role in elaborating the vernacular cultures and identities. As Bronner and Shulman (2006) elaborate in their study, Sanskrit was employed to articulate regional distinctiveness instead of occluding it.

compendiums comprised of two sections composed in metrical Sanskrit verses: namely, the *kośa prakaraṇa*, a bilingual Persian-Sanskrit lexicon, and the *vyākaraṇa prakaraṇa*, a section on the rules of Persian grammar. The *Pārasīprakāśa* (c. 1575) of Bihārī Kṛṣṇadāsa Miśra dedicated to Akbar and the *Saṃskṛtapārasīkapadaprakāśa* (1643) of Mālajit Vedāṅgarāya sponsored by Shāh Jahān are two prominent exemplars (see S. R. Sarma 2009). The former contains a general collection of Persian words, whereas, the latter includes a specialised lexicon on technical terms in Islamicate astrology/astronomy. It is doubtful if either of these manuals were ever sufficient to learn Persian. However, their value in promoting Persian as a language of sociopolitical influence in Mughal India is certainly conceivable.[19]

1.1.3 *Away from the Mughal court*

By the turn of the eighteenth century, the locus of Sanskrit patronage shifted from the Mughal court to the courts of the vassal states under Mughal suzerainty. Among these subimperial sponsors, the royal patronage of Mahārāja Savāī Jayasiṃha of Jayapura (Jaipur) is particularly pertinent to the history of Sanskrit astronomy. Savāī Jayasiṃha II (r. 1699–1743) was the Kachvāha Rajput King of Āmera (and later Jayapura) who invested in Sanskrit astronomy both academically and economically. He not only paid for the construction of five astronomical observatories in India but also instituted an ambitious project to translate Islamicate scientific works into Sanskrit; in particular, Arabic and Persian version of Greco-Islamicate mathematics and astronomy—and to a lesser extent, even the European astronomical tables brought to him by the Jesuits (S. R. Sarma 1998; Pingree 1999).[20]

19 A statement in support of this idea is found in the words of the Sanskrit scholar Paṇḍita Sūryadāsa Daivajña (b. 1508). Sūryadāsa wrote a versified glossary of Perso-Arabic astrological terms as a section of the fifth chapter in his *Siddhāntasaṃhitāsārasamuccaya* (1583). He begins the section by claiming (in v. 56) that the knowledge of the 'technical terms stated in the science of the foreigners' (*yavana-śāstra-uktā saṃjñā*) will be 'useful in the royal court' (*narapati-sabhā-upayogya*) and will also be 'beneficial to astrologers' (*upakāra-artha daivavidām*); see Minkowski (2004: p. 329–330) for the Sanskrit text of this verse, and also an overview of Sūryadāsa's contributions in promoting Islamicate astrology in Sanskrit. More generally, see Alam (2003) for an excellent study on the cultural and political role of Persian in the polity of Mughal India.

20 In her doctoral dissertation, Johnson-Roehr (2011) describes the sociopolitical impact of Savāī Jayasiṃha's urban observatories, in particular, the emplacement of ancillary knowledge-systems (like accounting, masonry, etc.) within the local landscape of his newly built city of Jayapura (Jaipur). Her observations locate these subsidiary activities within Jayasiṃha's programme of assimilating Islamicate and European astronomy, and in that capacity, offer an interesting parallel to the patronage of professional interpreters, scribes, accountants, and clerks in early-modern society of Mughal India (e.g., see Alam and Subrahmanyam 2011: Chapter 7 'The Making of a Munshī').

V. N. Sharma (1993) provides a descriptive account of the Hindu astronomers, astrologers, observers, and scribes recruited under Savāī Jayasiṃha's programme. Among these names, Jagannātha Samrāṭ (fl. c. 1720/40), Nayanasukhopādhyāya (fl. 1729), and Kevalarāma Jyotiṣarāya (fl. c. 1730/80) are three notable Hindu *jyotiṣīs* who translated the science of the *yavanas* (foreigners) into Sanskrit.[21] Table 1 lists some of the more prominent Sanskrit translations of Arabic and Persian works, particularly, those that were commissioned by Savāī Jayasiṃha in the early eighteenth century (Pingree 2003*a*: 131–151).[22]

It is worth noting that Savāī Jayasiṃha possessed a copy of Nityānanda's *Siddhāntasindhu* (c. early 1630s).[23] It is very likely he also possessed a copy of Nityānanda's *Sarvasiddhāntarāja* (1639). As Pingree (1999: 79) notes, the earliest version of Jagannātha Samrāṭ's *Samrāṭsiddhānta* (i.e., the *Samrāṭsiddhāntakaustubha* from 1726; the third entry in Table 1) includes the astronomical parameters of Ulugh Beg derived from Nityānanda's *Sarvasiddhāntarāja*. Pingree continues on to say: 'From Jagannātha's use of [the astronomical parameters] we come to realize what has long been suspected, that Nityānanda's arguments, originally advanced in 1639, finally found a receptive audience, nearly a century later, at Jayasiṃha's court' (p. 79). In fact, Nityānanda's technical vocabulary also provides some of the terminology with which Kevalarāma (see footnote 21) translates European astronomy into Sanskrit around the mid eighteenth century CE (Pingree 2003*b*: 283).

The method of translation at Savāī Jayasiṃha's court becomes evident with one of his astronomers' own statement on the process. Nayanasukhopādhyāya, in his *Ukarā* and his *Śarahatajkirā Virajandī* (the fourth and fifth entries in Table 1), expressly mentions Muḥammad Ābidda dictating the Arabic passages while he composes them into Sanskrit (S. R. Sarma 1998: 73-74). As Kusuba and Pingree

21 Kevalarāma authored several works at Jayasiṃha's court; one of them is believed to be the *Dṛkpakṣasāraṇī* (c. 1733), a Sanskrit adaptation of Philippe de La Hire's *Tabulae Astronomicae* (1702) based on its 1727 Latin edition (Pingree 1998). There is at least one other Sanskrit text, the *Phiraṅgicandracchedyopayogika* (c. 1732/24), also inspired by La Hire's work but collectively authored by the *jyotiṣīs* at Jayasiṃha's court (Montelle and Plofker 2018: 248–249; Pingree 2002).

22 These works are translations in an *explicit* sense; there are other works, mostly Siddhāntas composed in the late seventeenth- and early eighteenth-century Mughal India, that implicitly engage and discuss Islamicate astronomy. Nityānanda's *Sarvasiddhāntarāja* (1639), Munīśvara's *Siddhāntasārvabhauma* (1646), and Kamalākara's *Siddhāntatattvaviveka* (1658) are three canonical examples of Sanskrit texts that discuss Islamicate mathematical astronomy. More on this in § 2.

23 MS Museum 23 (444 folia) of the *Siddhāntasindhu* held at the Maharaja Sawai Man Singh II Museum at the City Palace of Jaipur attests that it was copied by Gaṅgārāma of Kaśmīra for Mahārāja Jayasiṃha on Thursday 6 April 1727 CE (stated on f. 443). A second note (in Hindi) appears on f. 444v indicating it copied (from an earlier copy?) by Gaṇgāyaratna on c. 24 May 1726 CE (Pingree 2003*a*: 142–143).

Date of composition	*Sanskrit text*
ante 1694	the *Hayatagrantha*, an anonymously authored Sanskrit translation of ʿAlī Qushjī's Persian text *Risāla dar ʿIlm al-Hayʾa* (1458) 'Treatise on Astronomy (*ʿilm al-hayʾa*)', edited by V. B. Bhaṭṭācārya (1967)
1726	the *Rekhāgaṇita* of Jagannātha Samrāṭ (1652–1744), a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's Arabic text *Kitāb Taḥrīr Uṣūl li-Uqlīdus* (c. 1248) 'The recension of Euclid's *Elements*', edited by Trivedî (1902)
c. 1726–1732	the *Samrāṭsiddhānta* of Jagannātha Samrāṭ, a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's Arabic recension *Taḥrīr al-Majisṭī* (1247) 'Commentary on [Ptolemy's] *Almagest*'; three versions of this text are attested: the earliest, called *Samrāṭsiddhāntakaustubha*, is from 1726, while the two later expanded versions are from 1730 and 1732 respectively; the text dated 1732 is edited by R. S. Sharma (1967)
1729	the *Ukarā* of Nayanasukhopādhyāya (with the assistance of Muḥammad Ābidda), a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's Arabic recension *Taḥrīr al-Ukarr* (1253) 'Commentary on [Theodosius'] *Sphaerica*', edited by V. B. Bhaṭṭācārya (1978)
1729	the *Śarahatajkirā Virajandī* of Nayanasukhopādhyāya (with the assistance of Muḥammad Ābidda), a Sanskrit translation of Chapter 11 from Book II of Naṣīr al-Dīn al-Ṭūsī's *al-Tadhkira fī ʿIlm al-Hayʾa* 'Memoirs on Astronomy' (1261–1274) with Niẓām al-Dīn al-Bīrjandī's *Sharḥ al-Tadhkira* (1507) 'Commentary on the *Tadhkira*', edited by Kusuba and Pingree (2001)
c. 1730	the *Yantrarājasya Rasāla* aliases *Vīsavāva*, *Yantrarājavicāraviṃśādhyāyī* of Nayanasukhopādhyāya (suspected), a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's Persian text *Risāla-yi Bīst Bāb dar Maʿrifat-i Usṭurlāb* 'Treatise in Twenty Chapters on the Knowledge of the Astrolabe' (c. 1240), edited by V. B. Bhaṭṭācārya (1979)

Table 1: Major Sanskrit translations of Arabic and Persian astronomical texts

(2001) remark, Nayanasukhopādhyāya 'did not simply render the Arabic commentary together with the original into Sanskrit literally, but expanded those passages that he found particularly difficult' (p. 7). This suggests that between Muḥammad Ābidda's dictation of the Arabic passages and Nayanasukhopādhyāya's translation of those passages into Sanskrit, they communicated directly or through an intermediary in a common link language (perhaps, a colloquial dialect of Hindavī, Brajabhāṣā, or Rājasthānī).

Bidirectional translations of texts between Sanskrit and other languages (e.g., vernaculars like Hindustānī or Bāṅglā, or even European languages like English or German) continued beyond the eighteenth century, with different methods and motivations (e.g., see Dodson 2005; Raina 2010; Gallien 2019). Texts in the exact sciences were included in many translation projects, and undoubtedly, they were repurposed to serve the ambitions of the benefactor and the beneficiary alike.

1.1.4 Why Nityānanda?

It is uncertain why Nityānanda was chosen to translate Mullā Farīd's Persian *Zīj-i Shāh Jahānī* into Sanskrit. Based on what we know, Nityānanda was not a decorated astronomer: he did not hold any titles like *Jotik Rāi* or *Vedāṅgarāya*, even though Shāh Jahān conferred such a title on Mālajit Vedāṅgarāya (fl. 1643) (see footnote 16). Nityānanda identifies himself in the colophon of his *Sarvasiddhāntarāja* (1639) as a Gauḍa Brahmin of Mudgala *gotra* (patronymic) from Indrapurī (Old Delhi), and provides a genealogy of his Brahmin ancestors beginning with his father: Nityānanda, son of Devadatta, son of Nārāyaṇa, son of Lakṣmaṇa son of Icchā Ḍulīnahaṭṭa (e.g., see Peterson 1892: 228). Beyond this register of names, we have no reliable information on who these other Brahmins were, where they came from, or what works they wrote (if any).

Until any new evidence suggests otherwise, we believe Nityānanda's association with the Mughal court begins with Āṣaf Khān employing him in c. post 1628.[24] As I describe below (in § 1.3), a royal decree (*farmān*) was issued to bring Muslim and Hindu astronomers together to prepare the *Zīj-i Shāh Jahānī* under Āṣaf Khān's supervision. This may have been the ticket for Nityānanda's entry to the Mughal court. His fluency in vernacular Hindi (as a resident of Delhi) and competency in Sanskrit astronomy (presumably, attested through testimony) might have brought him to Shāh Jahān's court seeking patronage as a Sanskrit *jyotiṣī*.

24 In contrast, Mullā Farīd first joined the service of Mirzā ʿAbdʾl-Raḥīm Khān-i Khānān—a prominent Mughal nobility during the reigns of the Mughal emperors Akbar and Jahāngīr, 'a man of the sword as well as of the pen' (Lefèvre 2014: 75)—in 1597 and remained in his service till he joined the court of Shāh Jahān in 1628 (Ghori 1985: 34).

We do not know whether Nityānanda continued to remain at the Mughal court after composing the *Siddhāntasindhu*, or even if his association was ever exclusive to begin with. His second book, the *Sarvasiddhāntarāja* (1639), is a complex syncretism of Sanskrit siddhāntic astronomy and Islamicate theories. To my knowledge, there are no explicit references to any patrons in this work; however, judging by the scale and scope of the work, it seems very likely that he had continued access to intellectual and financial resources throughout its production (more on this in Misra forthcoming).[25]

1.2 ISLAMICATE *ZĪJES* IN MUGHAL INDIA

By the seventeenth century, Arabic and Persian astronomical texts were regularly studied at Islamic institutions of higher learning (*madrasa*) in Mughal India; particularly, at those institutions that focused on teaching the rational sciences (*ʿulūm al-ʿaqlīyah*).[26] Ansari (1995: Table 1 on p. 278) lists the names of prominent Islamicate scholars whose works are extant in several copies in Indian libraries. It includes the works of Abū Naṣr Manṣūr b. ʿAlī b. ʿIrāq (d. 1036), Kūshyār b. Labbān al-Jīlī (d. 1029), Ḥasan b. al-Haytham (965–1041), Abuʾl-Rayḥān al-Bīrūnī (973–1048), Maḥmūd al-Jaghmīnī (c. early thirteenth century), Naṣīr al-Dīn al-Ṭūsī (1201–1274), Qutb al-Dīn al-Shirāzī (1236–1311), Jamshīd Masʿūd al-Kāshī (d. 1436), Sulṭān Ulugh Beg (1394–1499), and many others; also see Ansari (1995: Section III on pp. 279–281 and Appendix I on pp. 288–294). The large numbers of manuscript witnesses suggest the prevalence of these works in the repertoire of Muslim scholars (*ʿulamāʾ* or *fuḍalāʾ*) in early-modern India.

The lists of *zījes* enumerated in the *Āʾin-i Akbarī* of Abuʾl-Faḍl ʿAllāmī (1551–1602), the chronicler of Akbar, and the *Zīj-i Shāh Jahānī* of Mullā Farīd composed during the rule of Shāh Jahān provide further information on the astronomical tables in the imperial library (*kitābkhāna*) of early seventeenth-century Mughal India (Ghori 1985: Appendices A and B on pp. 45–48).[27]

25 A single extant manuscript of a text called the *Śāhajahāṃgaṇita*, allegedly authored by Nityānanda, is currently held at the Anup Sanskrit Library in Bikaner (MS 5291, Serial №787, 12 folia, injured, see Pingree 1970–94: CESS A3, p. 174a; Raja and M. K. Sarma 1993: 393). I have not been able to consult this manuscript to verify its professed authorship.

26 Sufi (1941: 1–88) provides an extensive chronological study of the evolution of curriculum in Indian *madrasas* through the dynastic rule of the Ghaznavids, the Ghurids, the Delhi Sultanates, and eventually the Mughals.

27 Seyller (1997) provides a comprehensive description and valuation of the manuscripts in the collections of the Mughal library. The paper begins by observing that '[s]hortly after the death of Emperor Akbar in 1605, an inventory of the vast holdings of the imperial Mughal library recorded a total of 24,000 volumes with a value of 6,463,731 rupees.' (p. 243).

An important *zīj* in these accounts is the *Zīj-i Jadīd-i Sulṭānī* (alias *Zīj-i Ulugh Beg* or *Zīj-i Saʿīd-i Jadīd-i Gūrgānī*) of Sulṭān Ulugh Beg composed by a collaborative team of astronomers (al-Rūmī, al-Kāshī, Ulugh Beg, and ʿAlī Qūshjī) at the Observatory of Ulugh Beg in Samarqand in 1438/39.[28] As Ansari (2015: p. 581a) notes, the *Zīj-i Ulugh Beg* was translated into Sanskrit (*Jīca Ulugbegī*[29]) by a consortium of Muslim and Hindu scholars led by Shāh Fatḥallāh Shīrāzī (d. 1589) during the reign of Akbar. From the sixteenth century, the preeminence of the *Zīj-i Ulugh Beg* in Mughal India made its structure the standard with which subsequent *zījes* were composed. The *Zīj-i Raḥīmī* and the *Zīj-i Shāh Jahānī*, both composed by Mullā Farīd, are two such examples.[30]

1.3 THE ZĪJ-I SHĀH JAHĀNĪ (C.1629/30) OF MULLĀ FARĪD

MULLĀ FARĪD'S *KĀRNAMĀH-I ṢAḤIB QIRĀN-I THĀNĪ, ZĪJ-I SHĀH JAHĀNĪ*[31] (*Zīj-i Shāh Jahānī* for short) is a set of astronomical tables written at the behest of Abuʾl-Ḥasan Āṣaf Khān (d. 1641), the prime minister (*vazīr-i āʿẓam*) and father-in-law to Shāh Jahān. It was commissioned to institute a new calendar of Shāh Jahān, the *Tāʾrīkh-i Ilāhī Shāhishānī*, beginning on the first day of Farvardin in his ascensional year 1037 AH (21 March 1628). This was in keeping with previous regnal year calendar like *Jalālī* era (epoch 21 March 1079) of the Seljuk Sultan Malik Shāh or the *Taʾrīkh-i Ilāhī* 'Divine Era' (epoch 20 March 1555/56) of Shāh Jahān's grand father Akbar. Ansari (2015: Section 3.2 on pp.583–585), Ghori (1985: 34–36), Rosenfeld and İhsanoğlu (2003: 357–358), and Rahman et al. (1982: 307) survey the context, the structure, and manuscripts of the *Zīj-i Shāh Jahānī*. For our present purpose, we note the following points from these surveys:

28 see Rosenfeld and İhsanoğlu (2003: 277–279), King et al. (2001: 54), and Kennedy (1956: pp. 127b–128a and pp. 166b–167b) for a descriptive survey of the contents and manuscripts of the *Zīj-i Ulugh Beg*.

29 The *Jīca Ulugbegī* (or *Ulakābegījīca*) is extant in a few fragmentary manuscripts containing only tables and star catalogues. The largest (and most complete) manuscript appears to be MS Museum 45 held at the Maharaja Sawai Man Singh II Museum at the City Palace of Jaipur. According to Pingree (2003*a*: 135) it contains 100 folia measuring 17 × 28½ cm, contains only tables written in Nāgarī numerals, and was acquired from Sūrata by Nandarāma Jośī for 20½ rupees.

30 Ansari (2015: Section 3.2 on pp. 582–583) reviews the structure and contents of Mullā Farīd's *Zīj-i Raḥīmī* (c. 1615/17) dedicated to his patron Mirzā ʿAbdʾl-Raḥīm Khān-i Khānān, a prominent Mughal nobility during the reigns of the Mughal emperors Akbar and Jahāngīr.

31 The *Kārnamāh-i Ṣaḥib Qirān-i Thānī, Zīj-i Shāh Jahānī* 'Grand Accomplishment of the Second Lord of the Conjunction, the *Zīj* of Shāh Jahān' uses the royal epithet of Shāh Jahān as the 'Second Lord of the Conjunction' born on the auspicious conjunction (*qirān*) of Jupiter and Venus at his natal hour on 5 January 1592 CE. The use of 'second' in the title is to establish a direct descent from the first Lord of Auspicious Conjunction, Sulṭān Amīr Tīmūr (Chann 2009: 1105–1106).

1. The *Zīj-i Shāh Jahānī* (like the *Zīj-i Ulugh Beg*) consist of a detailed prolegomenon (*muqaddima*) consisting of five sections (*qism*, pl. *aqsām*) followed by four discourses (*maqāla*, pl. *maqālāt*) on four different subjects, each containing several chapters (*bāb*, pl. *bībān*) that are further divided into sections (*faṣl*, pl. *fuṣūl*).
2. Mullā Farīd classifies the *Zīj-i Shāh Jahānī* as a *zīj-i ḥiṣābī* or a 'computational table that revises and updates the parameters' of the *Zīj-i Ulugh Beg* (and different from a *zīj-i raṣadī* or an 'observational table based on findings from direct observations').
3. A lack of time to conduct newer observations, in part due to the advancement of age and the ailing health of Mullā Farīd, meant that large parts of the *Zīj-i Shāh Jahānī* were reproductions of corresponding parts of the *Zīj-i Ulugh Beg*. However, as Ansari (2015: 585) notes, the tables in the *Zīj-i Shāh Jahānī* outnumber those in the *Zīj-i Ulugh Beg*. Mullā Farīd includes the auxiliary tables for simplification (*tashīl*) so that the true longitudes (*taqvīm*) of celestial objects can be computed directly (without any interpolation).
4. By a royal decree of Shāh Jahān, the *Zīj-i Shāh Jahānī* was to be translated into 'the language of Hindustan by Indian astronomers in consultation with Persian astronomers, for the sake of public utility'.[32] Ghori (1985: 34) also observes that the *Zīj-i Shāh Jahānī* was prepared by Mullā Farīd in 'collaboration of his brother Mullā Ṭayyib and other scholars of Muslim and Hindu astronomy under the over-all supervision of the Vazir Aṣif Khān [sic]'.

1.3.1 *Manuscripts of the* Zīj-i Shāh Jahānī

In this study, I outline the twenty-two chapters (*bībān*) in the second discourse (*maqāla-i duvum*) of the *Zīj-i Shāh Jahānī*, and among these, I examine the sixth chapter. To this end, I have consulted (parts of) the two manuscripts of the *Zīj-i Shāh Jahānī* that were available to me. Table 2 provides a description of these manuscripts and their assigned sigla.

To my knowledge, the *Zīj-i Shāh Jahānī* (or any part of it) has never been edited or translated into any major European or Indian (vernacular) language in modern times. Historically, the only translation of the *Zīj-i Shāh Jahānī* is Nityānanda's *Siddhāntasindhu* described in the next subsection.

32 Excerpted from the *Mulakhkhaṣ-i Shāhjahān Nāma*, an abridged history of Shāh Jahān written by his seventeenth-century court chronicler Muḥammad Ṭāhīr Khān, alias ʿInāyat Khān, see Ansari (2015) for Muḥammad Ṭāhīr Khān's Persian text (Appendix II. A4 on p. 597) and its English translation (p. 584a).

Siglum	*Manuscript description*
Sj_A	MS Ind. Inst. Pers. 12 from the Bodleian Library Oxford, entitled *Kâranâma i ṣâḥibkirân thânî zîj i shâhjahânî*, 380 folia (incomplete) with 25 lines per folio, 13 ¼ × 9 ⅜ inches, Persian Nastaʿlīq, written with red and black ink, c. seventeenth century CE (Beeston 1954: p. 61b, no. 2735). Mr Alasdair Watson, the Bahari Curator of Persian Collections at the Bodleian Library, very kindly provided me with photographs of folia that include the sixth chapter of the second discourse. The folio numbers do not appear on the images; Mr Watson identified them as ff. 21b–22a (personal communication). I have not had the opportunity to inspect the other folia of this manuscript. The summary of the Persian chapter-titles in § 4 rely entirely on the reading in MS Sj_B.
Sj_B	MS Or. 372 from the British Library London, labelled *Farìd Ibráhím Zíj E Sháhjaháni Persian* (on the microfilm cover), entitled کارنامه صاحبقران ثانی زیج شاه جهانی *Kārnamāh-i Ṣaḥib Qirān-i Thānī, Zīj-i Shāh Jahānī*, 419 folia with 31 lines per folio, 13 ¾ × 8 ½ inches, Persian Nastaʿlīq, treble-ruled text frame, c. seventeenth century CE (Rieu 1881: pp. 459b–460b). Folio numbers are written at the top left corner of *folium rectum* (b-side) in western Arabic numerals, (possibly) by a European owner/cataloguer/librarian. I am grateful to Dr Benno Van Dalen (from the *Ptolemaeus Arabus et Latinus* project at the Bayerische Akademie der Wissenschaften München) for providing a digitised black-and-white photocopy of this manuscript to me.

Table 2: Description of the manuscripts of the *Zīj i Shāh Jahānī*

1.4 THE *SIDDHĀNTASINDHU* (C. EARLY 1630) OF NITYĀNANDA

PAṆḌITA NITYĀNANDA MIŚRA completed his translation of Mullā Farīd's *Zīj-i Shāh Jahānī* in the early 1630s and named it *Siddhāntasindhu* 'the Ocean of Siddhāntas'. This enormous work occupied around 440 folia measuring 45 × 33 cm (approximately). At the time, ten copies of this work were made and distributed among the Muslim nobility of northern Mughal India (more on this in § 1.4.2). Today, however, only a handful of near-complete manuscripts of this work survive. And among these, the four manuscripts at the Maharaja Sawai Man Singh II Museum at the City Palace of Jaipur (India) are the best preserved copies. One of these manuscripts (Khasmohor 4960, part of the *khās muhr* or

Siglum	*Manuscript description*
Kh	MS 4962 from the Khasmohor Collection at the City Palace Library of Jaipur, entitled (in Hindustānī) पोथि सिद्धांतसिंधु की 'Book (*pothī*) of *Siddhāntasindhu*', 436 folia (incomplete: missing ff. 1 and 3; tears and damages on f. 2) with 21–30 lines per folio, 37 × 25 cm, Sanskrit Nāgarī, written with red and black ink parallel to the shorter edge, double-ruled text frame, left-binding with side-sewing stitches, red-and-blue striped cloth-covered boards and book flap, belonging to Jagannātha Jośī and acquired for 100 rupees, c. early eighteenth century CE (Pingree 2003*a*: 143). Folio numbers are written at the bottom left corner of *folium versum* in Nāgarī numerals by the same hand as the scribe. REMARK The metrical verses are often introduced by the word छंदः (*chaṃḍaḥ*) 'metre', e.g., f. 4v: 4, 15 Kh. Its abbreviated form छं (*chaṃ*) also appears in several places, e.g., on f. 5v: 7 Kh. Overall, Kh uses the double-*daṇḍa* '॥' to indicate half-stanza breaks, and frequently places the verse number, each time beginning with one, between two sets of double-*daṇḍas*, e.g., ॥ १ ॥. The prose passages are unnumbered. I gratefully acknowledge Dr Chandramani Singh, (retired) head curator of the Maharaja Sawai Man Singh II Museum Library, for her assistance in helping me get a digital copy of this rare and private manuscript.

Table 3: Description of the manuscript of the *Siddhāntasindhu*

'special seal' collection) bears the royal insignia of Shāh Jahān himself. Pingree (2003*a*: 138–143) describes these four manuscripts at the City Palace Museum Library in Jaipur. The catalogue references of the other (fragmentary) manuscripts located elsewhere can be found in Pingree (1970–94: CESS A3, p. 173b, and CESS A5, p. 184a).

1.4.1 *Manuscript of the* Siddhāntasindhu

Parallel to the selection from the *Zīj-i Shāh Jahānī*, I outline the twenty-two chapters (*adhyāyas*) of the second part (*dvitīya-kāṇḍa*) of the *Siddhāntasindhu*, and among these, I focus on the sixth chapter. I have consulted the only copy of the *Siddhāntasindhu* made available to me for this purpose by the City Palace Museum Library in Jaipur. A description of the manuscript, and its assigned siglum, is given in Table 3.

There are no published editions, translations, or studies of Nityānanda's *Siddhāntasindhu* to my knowledge.[33] At a very minimum, a comprehensive description of the structure and contents of the entire *Siddhāntasindhu* is certainly needed; however, such a task lies well beyond the scope of this study. Instead, I present below a few salient remarks from the *Siddhāntasindhu* that relate to the *Zīj-i Shāh Jahānī*.

1. *On the content of MS Kh* The *Siddhāntasindhu* also begins with a detailed prolegomenon (*granthārambha*, synonymous with *muqaddima*) consisting of five sections (*prakāra*, synonymous with *qism*) on ff. 3r–11v Kh[34] (incomplete). Thereafter, it follows the structure of the *Zīj-i Shāh Jahānī* with each part (*kāṇḍa*, identified with *maqāla*) addressing a different subject and containing several chapters (*adhyāya*, synonymous with *bāb*). However, only the first three *maqālāt* of the *Zīj-i Shāh Jahānī* appear to have been translated in the *Siddhāntasindhu* (as the three *kāṇḍas*); the fourth *maqāla* on miscellaneous astronomical calculations does not appear in Kh. A brief description of the content of Kh is as follows:

    - The first part (*prathama-kāṇḍa*) with seven chapter describing the different calendrical eras (*śāka*), viz. Arabic or Hijri (*ārbīya*), Shāh Jahān's (*shāhjahāṁnīya*), Roman (*raumīya*), Persian (*phārasīya*), Malakī/Jalālī (*malakīya*), Saṃvat (*Hindukīya*), and Chinese-Uighūr Animal (*khitāyīya-turkīya*) on ff. 12r–16v Kh.
    - The second part (*dvitīya-kāṇḍa*) with twenty-two chapters describing various topics on finding the desired time (*abhimata-samaya*) and the ascendant at that time (*tātkālika-lagna*), as well as other topics related to it, on ff. 17r–28v Kh. More on this in § 4.
    - Tables (*koṣṭhakas*) from ff. 29r–97v Kh.
    - The third part (*tṛtīya-kāṇḍa*) with fifteen chapters describing the true (*sphuṭa*) position and motion of celestial objects, and other topics related to it on ff. 98v–111v Kh.

33 Peterson (1892: 231–232) provides an excerpt containing the first thirty-two verses (from the prolegomenon) and the colophon (from the end of the second part) of Nityānanda's *Siddhāntasindhu*. This is presumably transcribed from MS RORI (Alwar) 2627 = MS 2014 Alwar, 441 folia, copied in 1855 CE (Pingree 1970–94: CESS A5, p. 184a); however, Peterson does not identify the shelf mark of the manuscript. Minkowski (2014: 128–129) makes a few remarks on Nityānanda's *Siddhāntasindhu* (based on Peterson's extract), while Pingree (2003*b*: 269–27) summarises (very briefly) his observations on the *Siddhāntasindhu* based on the manuscripts held at the Maharaja Sawai Man Singh II Museum at the City Palace of Jaipur.

34 I cite manuscript references in the format ⟨f. folio$_{\#}$ Siglum⟩ or ⟨f. folio$_{\#}$: line$_{\#}$ Siglum⟩ throughout this paper. For instance, 'f. 22r: 9–11 Kh' indicates lines 9 to 11 on f. 22r in Kh.

- Tables (*koṣṭhakas*) from ff. 112r–436v Kh.

2. *On Shāh Jahān* In the preamble, Nityānanda extols Shāh Jahān with his encomiastic poetry (e.g., see Minkowski 2014: 129) and transliterates his Persian regnal epithet into Nāgarī (on f. 5v: 15–16 Kh) as

अबल-मुजफर-शाहिब्बदीन-	*abala-mujaphara-śāhibbadīna-*
महम्मद-साहिब-किरान-	*mahammada-sāhiba-kirāna-*
सानी-शाहजहा-बादिशाह-गाजी	*sānī-śāhajahā-bādiśāha-gājī*

In his *Pādshāhnāma*, the seventeenth-century Mughal chronicler ʿAbd al-Hamīd Lāhūrī states that upon ascending to the throne, Prince Shahāb al-Dīn Muḥammad Khurram (Shāh Jahān) assumed the regnal name 'Abūʾl-Muẓaffar Shahāb al-Dīn Muḥammad Ṣāhib-i Qirān-i Thānī' (Elliot 2013: 6). Among several other imperial epithets, Shāh Jahān was called صاحب قران ثاني (*ṣāhib-i qirān-i thānī*) 'Second Lord of the Conjunction', پادشاه غازی (*pādshāh-i ghāzī*) 'Conqueror of Emperors' and شاه جهان (*shāh-i jahān*) 'King of the World'.
Nityānanda traces the male ancestors of Shāh Jahān from Tīmūr (*taimūra*), Mīrān Shāh (*mīrā-śāhā*), Sulṭān Muḥammad (*sullā-mahaṃma*), Abū Saʿīd (*abūsayīda*), Umar Shaykh (*umara-śekha*), Bābur (*bābara*), Humāyūn (*humāū*), Akbar Shāh Jalāl al-Dīn (*akabaraḥ śāhajallāladīna*), Jahāngīr (*śrī-jahāṃgīra*), and finally, Shāh Jahān (*śrīmān-sāhajahāṃ*) (Peterson 1892: vv. 5–11 on p. 230).[35]

3. *On Āṣaf Khān* Abu ʾl-Ḥasan Āṣaf Khān, the prime minister (*vazīr-i āʿẓam*) of Shāh Jahān, is mentioned by name in the *Siddhāntasindhu*. On f. 2v: 10–11 Kh, we find the name **मन्त्री वासाफखाँ** (*mantrī-vāsapha-khāṁ*) 'Minister Āṣaf Khān'.
Through vv. 21–23 on the same folio (lines 8–18), Nityānanda generously praises him as **यो राज्याह्वयमण्डपस्य सुदृढः स्तम्भः** (line 15) 'he who is the steadfast pillar (*sudṛḍha-stambha*) of [this] pavilion called the Empire (*rājyāhvaya-maṇḍapa*)' and **वर्णाश्रमपालयत** (lines 17–18) '[he who is] protecting the [Hindu social system of] *varṇāśrama*'.

4. *On Mullā Farīd* Nityānanda identifies Mullā Farīd by his name. On f. 6r: 2 Kh, Nityānanda calls him **मुल्लाफरीदं इबराहिमपुत्रं ढिल्लीनिवासिनं** 'Mullā Farīd (*mullā-pharīda*), the son of Ibrāhīm (*ibarāhima-putra*) [and] resident of Delhi (*ḍhillī-nivāsin*)'. This description agrees with *ibn* [*Ḥāfiẓ*] *Ibrāhīm* 'son

35 MS Kh begins on f. 2r in the middle of describing the genealogy of Shāh Jahān. With the first folio missing and heavy damage to the second, I have relied on Peterson's transcription (see footnote 33) to fill in the missing parts.

of Ibrāhīm, [a man who has memorised the Qurʾān]' and *Dehlavī* 'resident of Delhi' in Mullā Farīd's full name.

5. *On the 'Zīj-i Shāh Jahānī'* Further along, on f. 6v: 19–20 Kh, we find the name of Mullā Farīd's text, transliterated into Nāgarī from the Persian *Kārnamāh-i Ṣaḥib Qirān-i Thānī, Zīj-i Shāh Jahānī*, as

कारनामै-साहिब-किरान-सानी	*kāranāmai-sāhiba-kirāna-sānī*
जीच-शाह-जहानी	*jīca-śāha-jahānī*

6. *On 'zīj' and its types* Nityānanda first distinguishes between the terms *zīj*, *tashīl*, and *taqvīm* on f. 7r: 9–10 Kh. According to him,

> जीच इति सिद्धान्तः । तसहील इति सारणी । तकवीम इति ग्रहस्फुटत्वम् ।
>
> '*zīj* (*jīca*) is Siddhānta (canon); *tashīl* (*tasahīla*) is *sāraṇī* (table); *taqvīm* (*takavīma*) is the true position of a celestial object (*graha-sphuṭatva*) [in other words, an ephemeris].'

On f. 8v: 2–3 Kh, he defines a *zīj* as

> यस्मिन्ग्रन्थे स्थूलसूक्ष्मगणितानि भवन्ति तस्य नाम जीच इति ।
>
> 'The book (*grantha*) in which both gross (*sthūla*) and subtle (*sūkṣma*) computations (*gaṇita*) are found, that is called a *zīj* (*jīca*)'.

Nityānanda, like Mullā Farīd, also classifies *zīj* into the two categories of *zīj-i raṣadī* and *zīj-i ḥiṣābī*:

- On f. 7v: 4–5 Kh, he defines **जीच-रसदी** (*jīca-rasadī*) as that work (*tantra*) which is well-established (*dṛḍhī-kṛtya*) by the rules of observations (*rasada-vidhāna*) and state the motion of celestial objects (*graha-bhukti*) with tables (*koṣṭhakas*); and
- On f. 7v: 27–19 Kh, he defines **जीच-हिसाबी** (*jīca-hisābī*) as the work containing tables (*koṣṭhakas*) that correct (*śodhyate*) previous tables in the table-writing tradition (*koṣṭhaka-lekhaka-paramparā*) or those that bring out the genuine result (*vāstava-phala*) by simple procedures (*sugama-prakāra*) of computations (*gaṇita*).

7. *On Ulugh Beg and other Islamicate astronomers, and their 'zīj'* Nityānanda identifies Ulugh Beg by name in several places in the preamble. For instance, on f. 7r: 26 Kh, he refers to Ulugh Beg as **मिरजा उलग-बेग** (*mirajā ulaga-bega*), and on the very next line, informs us of Ulugh Beg's demise with **परमेश्वरस्तस्य स्वर्गवासं करोतु** 'May God (*parameśvara*, lit. 'supreme lord') grant him residence in heaven (*svargavāsa*)'. The *Zīj-i Ulugh Beg* is translated as **जीच-उलग-बेगी** (*jīca-ulaga-begi*) on f. 7v: 5 Kh.

Along with Ulugh Beg, Nityānanda also described the names and works of several Islamicate astronomers (on ff. 7v–8v Kh). For example:

- the **जीच-जामे** and **जीच-बालिग** of **गोशियार**
  al-Zīj al-Jāmiᶜ (*jīca-jāme*) and *al-Zīj al-Bāligh* (*jīca-vāliga*) of Kūshyār b. Labbān al-Jīlī (*gośiyāra*), or
- the **जीच-खाकानी-तकमील-जीच-यीलखानी** of **मौलाना जमशेद् काशी**
  Zīj al-Khāqānī fī Takmīl al-Zīj al-Ilkhānī (*jīca-khākānī-takamīla-jīca-yīlakhānī*) of Jamshīd Masᶜūd al-Kāshī (*maulāna-jamaśeda-kāśī*).

The names of these *zīj*, and the order in which they are listed, appear to be identical in both the *Zīj-i Shāh Jahānī* and the *Siddhāntasindhu*.[36]

Motivation and purpose of composition The twenty-fourth verse from the prolegomenon of Nityānanda's *Siddhāntasindhu* is barely legible on the damaged second folio (verso) of MS Kh; however, it is attested in Peterson (1892: 231) from the Alwar manuscript. The verse (in the *śārdūlavikrīḍita* metre) describes how Āṣaf Khān, having derived this inspiration (*preraṇā*) from Shāh Jahān, ordered Nityānanda to compose a proper treatise (*su-tantra-karaṇe*) for the benefit of people (*loka-upakāra*).[37] Therefore, as Nityānanda says, he endeavoured to compose (*kartum samīhe*) to compose the *Siddhāntasindhu*, a pure (*amala*) and clear (*sphuṭa*) Ocean of Siddhāntas (*siddhānta-sindhu*), resembling the illustrious *Zīj-i Shāh Jahānī* (*śrīmat-sahājahāṃ-prakāśam*).

Style of composition Nityānanda's *Siddhāntasindhu* is a mixture of prose-sentences (*gadya*) and metrical verses (*padya*). The transition from prose to poetry is ubiquitous throughout the text. It is worth noting that most *explicit* Sanskrit translations of Islamicate astronomical texts (e.g., the texts listed in Table 1) are entirely in prose. I discuss a few aspects of Nityānanda's choice of using prose and poetry in relation to Part II.6 in § 2.3.1.

1.4.2 *Circulation of the* Siddhāntasindhu

According to two of the four manuscripts of Nityānanda's *Siddhāntasindhu* held at the Maharaja Sawai Man Singh II Museum at the City Palace of Jaipur, there were nine copies of the *Siddhāntasindhu* prepared for distributing among notable seventeenth-century Mughal elites (mostly, Mughal Ṣūbadār s or Provincial

36 Ghori (1985: 48) provides the list of *zīj* in Mullā Farīd's *Zīj-i Shāh Jahānī*, see discussion in § 1.2.

37 Nityānanda eulogises Shāh Jahān as the 'crest jewel of the ornamental crown of kings' (*nṛpāla-mukuṭa-ālaṅkāra-cūḍāmaṇi*)—an epithet he repeats in the colophons of every part of the *Siddhāntasindhu*, e.g., see Part II colophon on p. 84.

Governors), and an author's copy for Nityānanda (Pingree 2003*a*: 142). A note, in vernacular Hindi, on f. 443v of MSS Khasmohor 4960 and Museum 23,[38] begins by stating that the original Sanskrit text (*jīcamūlakarī*) remains in the library (*kitābkhāṃnā*) of the emperor (*pātiśāha*, Pādishāh). Individual copies of the text were given to the following recipients:

1. ᶜĀẓam Khān (*ājama khāṃ*) of Bengal (*ba*[*ṃ*]*gāla*), the governor of Bengal from 1632 to 1635;
2. ᶜAbdallāh Khān Fīrūz Jung (*avdullaha khaṃ*) of Patna (*paṭaṇā*), the governor of Bihar from 1632 to 1639;
3. Ṣāḥib Ṣuba[dār?] of Benaras (*banārasī sahava sūva*/*mūva*), unidentified;
4. Iᶜtiqād Khān (*itakada khāṃ*) of Delhi (*dillī*), also known as Mirzā Shāpūr (d. 1650), the brother of Āṣaf Khān;
5. Khwāja Ṣābir Khān-i Daurān (*khāṃ nadorā*) of Ujjain (*ujjayaṇa*), also known as Naṣīrī Khān (*navaśeri khāṃ*), governor of Malwa from 1631 to 1638;
6. Mahābat Khān Khān-i Khānān (*mahavata khā*[*ṃ*] *khāṃnakhāṃnā*) in Burhanpur (*burahānapura*), c. post 1633;
7. Vazīr Khān (*ujīra khāṃ*), also known as Ḥakīm Shaykh ᶜIlm al-Dīn Ansārī, of Lahore (*lāhora*), governor of Lahore from 1628 to 1639;
8. Ẓafar Khān Aḥsan (*japhara khāṃ*) of Kashmir (*kaśmīra*), the governor of Kashmir from 1632 to 1639 and from 1642 to 1646; and
9. an unnamed recipient in Multan (*mulatāna*).

38 MS Khasmohor 4960 belonged to Pīthīnātha in 1717; the horoscope of his son (dated Thursday 10 October 1717) is written on f. 443. It is said to have been previously purchased from Manasārāma in 1696 for 250½ rūpas (f. 444). Both these notes appear in vernacular Hindi (Pingree 2003*a*: 138–142). The provenance of MS Museum 23 is previously described in footnote 23.

2 THE SANSKRIT TRANSLATION OF A PERSIAN *ZĪJ*

2.1 CHRONOLOGY AND INFLUENCE

Nityānanda's *SIDDHĀNTASINDHU* was completed in the early 1630s, making it one of the earliest Sanskrit translations of a Persian *zīj*. The *Jīca Ulugbegī*, a Sanskrit translation of *Zīj-i Ulugh Beg* commissioned during Akbar's reign (ante 1605), is perhaps the earliest example. However, the extant fragmentary manuscripts only contain tables and star catalogues (see footnote 29) and not the canon (the text associated with the tables, often describing the theory and use of the tables).[39]

In contrast, as § 1.4 describes, the *Siddhāntasindhu* includes tables as well as three (out of the four) distinct portions (*kāṇḍa* 'part' in Sanskrit or *maqālāt* 'discourse' in Persian) of the canon of *Zīj-i Shāh Jahānī*. The full extent of similarity between the content of these two texts can only be determined by an extensive future study; for our present discussion, however, we note that the *Siddhāntasindhu* expressly declares itself to be a Sanskrit version of the Persian original. Other Sanskrit texts in mathematical astronomy, e.g., the three Siddhāntas mentioned in footnote 22, discuss or dismiss Islamicate ideas but they are not translations of any particular text.

The only other Sanskrit 'translation' that could predate *Siddhāntasindhu* (early 1630s) is the anonymously authored *Hayatagrantha* written sometime before 1694 (see Table 1). Pingree (1978: 327) correctly identifies the *Hayatagrantha* as a translation of ʿAlī Qūshjī's Persian *Risāla dar ʿIlm al-Hayʾa* (dedicated to the Ottoman Sulṭān Meḥmed II, r. 1451–1481). ʿAlī Qūshjī's work was known to the Mughal court of Humāyūn (r. 1530–56) via a commentary on it, the *Sharḥ-i Risāla dar ʿIlm al-Hayʾa* written by Muṣliḥ al-Dīn Muḥammad al-Lārī (d. 1572) and dedicated to his patron Humāyūn (Pourjavady 2014: 296).

39 The *Jīca Ulugbegī* was prepared by a consortium of astronomers led by Amīr Fatḥallāh of Shīrāz, with the assistance of Sanskrit interpreters (see § 1.1.2). As S. R. Sarma (2000: 367) has pointed out, some of these interpreters were Sanskrit *jyotiṣī*s: e.g., Kishan Joshī is identified as Kṛṣṇa Daivajña (fl. *c.*1600/25). If the authors' version of *Jīca Ulugbegī* contained the canon of the *Zīj-i Ulugh Beg*, the following two reasons make the loss of the Sanskrit canon a notable (and regrettable) event:

a. Mullā Farīd copied large parts of the *Zīj-i Ulugh Beg* (almost) verbatim in his *Zīj-i Shāh Jahānī*; these parts have been translated by Nityānanda in his *Siddhāntasindhu*. The Sanskrit canon in the *Jīca Ulugbegī* may have served as Nityānanda's model text to recopy just as easily as the *Zīj-i Ulugh Beg* served Mullā Farīd.

b. Mullā Farīd was a direct pupil of Amīr Fatḥallāh of Shīrāz, and is believed to have 'learned the rational sciences (*ʿUlūm-i ʿAqlīyah*) including astronomy and astrology' from him (Ansari 2016: 720). This suggests that, at the very least, Mullā Farīd (and by association, Nityānanda) would have been familiar with a version of the *Jīca Ulugbegī* closer to the original than what is currently extant.

Following the *Sharḥ-i Risāla dar ʿIlm al-Hayʾa*, the *Hayatagrantha* also discusses an assortment of topics (*prakaraṇa*) on planetary motion (*graha-gati-nirupaṇa*) and the Earth-sphere (*bhūgola-varṇana*) in two chapters (*adhyāya*). In each topic, it explains Islamicate astronomical terms and provides equivalent Sanskrit expressions for them. V. B. Bhaṭṭācārya (1967: p. 3 of the preface) thinks the *Hayatagrantha* is either a translation (*anuvāda*) of the Arabic text (*arabī-deśasya grantha*) or a paraphrase of its summary (*sāraṃ gṛhitvā likhita*); Pingree (1996) adds to that by suggesting the author was 'helped by a collaborator who was versed in Persian and Islamic astronomy, at least at a level sufficient for understanding the *Risālah*' (p. 475).[40]

Beyond these speculations on the nature of the *Hayatagrantha*, its influence on Nityānanda's *Siddhāntasindhu* is what concerns us here, and this is a difficult thing to ascertain at the present time. At the very outset, the anonymous authorship and vague timeline of the *Hayatagrantha* make it problematic to situate it in relation to the *Siddhāntasindhu*. The Sanskrit words for Islamicate astronomical terms in both these texts are quite similar; however, their presentations often differ. The *Hayatagrantha* includes transliterations of Arabic/Persian technical words along with their equivalent expressions in Sanskrit, whereas the *Siddhāntasindhu* translates Islamicate terms into Sanskrit without (always) transliterating the original Arabic/Persian word.[41]

For example, the *Hayatagrantha* glosses the Persian word बाअद्कोकिब (*bāad-kokiba*) and the Sanskrit word स्पष्ट-क्रान्ति (*spaṣṭa-krānti*) as the 'true declination' of a celestial object (V. B. Bhaṭṭācārya 1967: p. 19, lines 2–4). Nityānanda also refer to the 'true declination' (of celestial objects) with the Sanskrit word स्पष्ट-क्रान्ति (*spaṣṭa-krānti*); however, he does not transliterate the corresponding Persian technical expression used by Mullā Farīd, namely بعد کواکب از معدّل النهار (*buʿd-i kawākib az muʿaddil al-nahār*) the 'distance of a celestial object from the celestial equator'. (See the chapter-titles of Discourse II.6 and Part II.6 in § 4, page 75).

Nevertheless, the use of the same Sanskrit words to translate Islamicate astronomy does not establish an interdependence between these texts per se. It could

40 According to Pingree (1970–94: CESS A4, p. 57ab), there are seven extant manuscripts of the *Hayatagrantha*, the earliest of which was copied in Oudh (Uttar Pradesh) in 1694. V. B. Bhaṭṭācārya's editions is based on three manuscripts held at the Sarasvatī Bhavana Granthālaya in Varanasi. In his preface (p. 12), he cites internal evidence from the manuscripts to suggest (erroneously) that the *Hayatagrantha* was composed in Kāśī in the eighteenth century (see Pingree 1978: 326–327).

41 It is worth noting that Nityānanda's *Siddhāntasindhu* is not sanitised of all Arabic or Persian words. There are several instances where Islamicate names of authors, works, calendrical elements, etc. are transliterated in Nāgarī (e.g., the excerpts in § 1.4). The text from the second part (*dvitīya kāṇḍa*) indicates that Nityānanda translates Arabic/Persian astronomical terms into equivalent (or original) Sanskrit expressions without referring to the original words.

also indicate a common written source (e.g., a bilingual technical lexicon) or point towards a more institutionalised setup (like at the scriptoriums or *maktab-khānas*) where these translations were produced. The emergence of a common technical vocabulary is then another aspect of cross-traditional discourses that occurred in the seventeenth century, making this a topic of exploration for future studies.

2.2 THE *SIDDHĀNTASINDHU* PART II: CONTENT AND CONTEXT

THE SECOND PART (*DVITĪYA-KĀṆḌA*) OF NITYĀNANDA'S *SIDDHĀNTASINDHU* includes twenty-two chapters on various topics that help determine the time of rising (*udaya-samaya*) and degrees of ascension (*udaya-aṃśa*) of the zodiacal signs at one's local latitude. The arrangement of the chapters in the *Siddhāntasindhu* follows the order of the twenty-two chapters in the second discourse (*maqāla-i duvum*) of the Mullā Farīd's *Zīj-i Shāh Jahānī* identically. Table 4 provides a chapter-wise list of topics covered in the *Zīj-i Shāh Jahānī* Discourse II and *Siddhāntasindhu* Part II.

The Persian and Sanskrit chapter-titles from these two texts, along with my English translations of the titular text, are presented in parallel in § 4. A full list of Persian and Sanskrit technical expressions in the respective chapter-titles of *Zīj-i Shāh Jahānī* Discourse II and *Siddhāntasindhu* Part II is included in the glossary (beginning on page 115) grouped under their common English translations. I offer below a few general remarks on the language and scope of these chapters.

1. Mullā Farīd's Persian text describes the computations without necessarily defining the terms first. In contrast, Nityānanda's discussions often begin with definitions (*lakṣaṇas*) of technical terms before describing the computational methods. The *Zīj-i Shāh Jahānī* is written in the format of a traditional *zīj*, and accordingly, it assumes its readers are familiar with technical expressions in Arabic/Persian. Nityānanda's *Siddhāntasindhu*, however, describes Islamicate astronomy in Sanskrit to readers largely unfamiliar with the form or the language of the text. The prefatory definitions, along with the use of typical Sanskrit deictic words (like *atha* 'now', *tat* 'its/their', *tatra* 'there', etc.) to introduce them, suggest an emphasis on communicating ideas effectively rather than simply translating the Persian text.
2. A salient aspect of Nityānanda's translation is *localisation*; in other words, adapting the foreign content to suit the local context. The passages in his Sanskrit translation (of the second part) explain technical terms in greater detail, while his Sanskrit vocabulary preserves the meaning of Arabic/Persian words without referring to them expressly. Beyond these communicative and semantic measures, Nityānanda also changes the context in which these foreign computational methods are applied.

Chapter	*List of topics*
II.1	Sexagesimal place-values of digits
II.2	Method of interpolation between successive entries in a table
II.3	Calculating Sine and Versed Sine values
II.4	Calculating the shadow of a gnomon (i.e., Cotangent values)
II.5	Declination of the zodiacal signs
II.6	Calculating the true declination of a celestial object
II.7	Calculating the maximum elevation and depression of a celestial object
II.8	Right ascensions of the zodiacal signs at the terrestrial equator
II.9	Calculating the equation and hours of daylights at a terrestrial location
II.10	Calculating the oblique ascensions of the zodiacal signs
II.11	Inverse calculation of the right ascensions of the zodiacal signs from their oblique ascensions
II.12	Calculating the right ascension and ecliptic longitude of a zodiacal sign culminating at the time of rising of a celestial object
II.13	Calculating the right ascension of celestial objects at the time of their rising and setting (at the local horizon)
II.14	Calculating the azimuth from the altitude of a celestial object
II.15	Calculating the altitude from the azimuth of a celestial object
II.16	Determining the line of the local meridian
II.17	Determining the latitude and longitude of a terrestrial location
II.18	Calculating the zenith-distance of the nonagesimal point
II.19	Calculating the distance (in degrees) between two celestial objects
II.20	Determining the direction of Mecca/Kāśī from a terrestrial location
II.21	Determining the ascendant zodiacal sign (at the local horizon) corresponding to the altitude of a celestial object
II.22	Determining the altitude of a celestial object corresponding to an ascending zodiacal sign (at the local horizon)

Table 4: List of topics commonly discussed in the twenty-chapters of the *Zīj-i Shāh Jahānī* Discourse II and the *Siddhāntasindhu* Part II

For example, the twentieth chapter in the second discourse of the *Zīj-i Shāh Jahānī* describes the method to determine the azimuth (and inclination) of *qibla*; in essence, the direction of Mecca. Nityānanda translates this chapter as the method to determine the direction of Kāśī. Having first discussed the mathematics of finding the direction of Kāśī from one's own location, he then goes on to apply the method to find the directions of other cities like Agra (*argalapura*) and Mecca (*makkaapura*) as illustrative examples (*udāharaṇa*). His translation not only captures the mathematical essence of the chapter from the *Zīj-i Shāh Jahānī* but also translates the cultural context of locating sacred and imperial cities.

3. The ability to translate Arabic/Persian technical terms into Sanskrit requires a conceptual understanding of both Islamicate and Sanskrit astronomy, as well as a linguistic competence in navigating between these languages. Nityānanda's translations, presumably mediated through vernacular Hindi, reflect his command on the language of Sanskrit astronomy. In some instances, his expressions are literal translations (*śabda-anuvāda*) of Arabic/Persian words; for example, ascendant طالع (*ṭāliᶜ*) as **लग्न** (*lagna*), genus [of digits] جنس (*jins*) as **जाती** (*jātī*),[42] or line of midday خطّ نصف النهار (*khaṭṭ niṣf al-nahār*) as **मध्याह्न-रेखा** (*madhyāhna-rekhā*). In other instances, they appear to be figurative translations (*bhāva-anuvāda*) based on an implied equivalence of technical meaning; for example,
   - distance of a celestial object from the celestial equator بعد كواكب (*buᶜd-i kawākib*) as true declination **स्पष्ट-क्रान्ति** (*spaṣṭa-krānti*),
   - equation of daylight تعديل النهار (*taᶜdīl al-nahār*) as ascensional difference **चर** (*cara*), or
   - latitude of the visible climate عرض اقليم رؤيت (*ᶜarḍ-i iqlīm-i ruʾyat*) as zenith distance of the nonagesimal point **दृक्क्षेप** (*dṛkkṣepa*).
4. In the colophon, Nityānanda states that the second part contains discussions 'accompanied by many statements and rationales on the "three questions"' (*tripraśna-pracura-ukti-yukti-sahita*). The *tripraśnādhikāra* is a separate chapter (*adhyāya* or *adhikāra*) in Sanskrit siddhānta s that discuss methods to find the cardinal directions (*diś*), the local latitude (*deśa*), and the times (*kāla*) of various celestial and terrestrial phenomena. By referring to

42 The Persian word جنس (*jins*) derives from the Greek word γένος (*genos*) that indicates a social group of common descent; the Sanskrit words **जाती** (*jātī*) and **गण** (*gaṇa*) are semantically equivalent to genus, and hence applied to identify digits (in a number) that belong to a particular class, see Rosenfeld and Hogendijk (2003: footnote 29 on p. 37).

the *tripraśna*, Nityānanda again bring a familiar context to situate an otherwise curious collection of chapters. In fact, the practice of writing benediction verses (*maṅgalācaraṇa*) at the beginning of every part of the book and a closing colophon at the end of each part is a Sanskrit siddhāntic trait not seen in in Islamicate *zīje*s.

2.3 THE *SIDDHĀNTASINDHU* PART II.6: STRUCTURE AND LANGUAGE

THE SIXTH CHAPTER (*saṣṭhādhyāya*) from the second part of Nityānanda's *Siddhāntasindhu* describes three methods to compute the true declination of a celestial object. A celestial object is variously understood as a planet, a star, or an asterism that moves in the celestial sphere. Typically, this object posses a non-zero ecliptic latitude and hence its declination is different from the Sun that moves on the ecliptic. Nityānanda methods to compute the true declination of such an object are identical to those stated by Mullā Farīd in the sixth chapter of the second discourse of his *Zīj-i Shāh Jahānī*. An edition of the original text from Mullā Farīd's *Zīj-i Shāh Jahānī* Discourse II.6 and Nityānanda's *Siddhāntasindhu* Part II.6, along with my English translations of corresponding Persian and Sanskrit passages, are included in §§ 5 and 6 separately. The technical glossary (beginning on page 115) also includes a list of technical expressions found in the Persian and Sanskrit passages of this chapter.

These methods rely on astronomical quantities that are distinctly Islamicate in their origin, e.g., the second declination of a celestial object or the arc of maximum argument of the distance. However, Nityānanda's exposition of these Islamicate methods is uniquely original in its presentation and style. In the following paragraphs, I present a few remarks on the structure and the language of Nityānanda's Sanskrit text in comparison with Mullā Farīd's Persian. A detailed mathematical analysis of these methods is to appear in Misra (forthcoming).

2.3.1 *Structure of the text*

The methods to compute the distance of a celestial object from the celestial equator (*buʿd-i kawkab az muʿaddil al-nahār*) in the *Zīj-i Shāh Jahānī* Discourse II.6 are translated in the *Siddhāntasindhu* Part II.6 as methods to compute the true declination (*spaṣṭa-krānti*). In §§ 5 and 6, I have grouped the Persian and Sanskrit text of this chapter into comparable passages (numbered '[1]', '[2]', etc.) to highlight their grammatical and mathematical likeness. (see my editorial conventions in § 3.4.2.) Table 5 provides an outline of the passages in the two texts with a brief description of their content.

As Table 5 shows, Nityānanda's third method includes four additional passages [α–δ] in metrical verses that are not found in Mullā Farīd's Persian text. The mathematics of the third method requires a knowledge of several astronom-

Passages in II.6		*Description*
Zīj-i Shāh Jahānī	*Siddhāntasindhu*	
		First Method
[1] prose	[1] verse	Definition of argument of the distance
[2] prose	[2] verse	First method to compute the Sine of the true declination
		Second Method
[3] prose	[3] verse	Second method to compute the Sine of the true declination
[4] prose	[4] prose	Alternative second method to compute the Sine of the true declination (using tables)
[5] prose	[5] prose	Case one: no [ecliptic] latitude
[6] prose	[6] prose	Case two: [ecliptic] latitude with no [first] declination
[7] prose	[7] prose	Case three: [first] declination equals the obliquity of the ecliptic
		Third Method
–	[α] verse	Definitions of the solstitial colure and the circle congruent to the ecliptic
–	[β] verse	Definition of the arc of maximum true declination
–	[γ] verse	Definition of the arc of maximum latitude
–	[δ] verse	Definitions of the congruent arc and the congruent complementary arc
[8] prose	[8] verse	Calculating the Sine of the distance along the 'circle congruent to the ecliptic' from the solstice
[9] prose	[9] verse	Calculating the arc of maximum latitude
[10] prose	[10] verse	Calculating the arc of maximum argument of the distance
[11] prose	[11] verse	Third method to compute the Sine of the true declination

Table 5: Description of the passages in *Zīj-i Shāh Jahānī* Discourse II.6 (in § 5) and *Siddhāntasindhu* Part II.6 (in § 6)

ical concepts that are not very commonly known in Sanskrit astronomy. Nityānanda defines these Sanskrit terms in the four passages before using them in the third method of computation. His style of interspersing the (*mūla*-like) translations with (*bhāṣya*-like) commentarial passages, in metrical Sanskrit, is as unique as the content of these passages themselves. These extra verses reveal his intentions (and ability) to communicate this new astronomy systematically and not slavishly translate the Persian into Sanskrit. Nityānanda's *Siddhāntasindhu* is among the earliest texts to Sanskritise Islamicate astronomy; and in doing so, conceive several original (or equivalent) Sanskrit expressions for Islamicate technical terms.

Mixture of prose and poetry Nityānanda's Sanskrit translation of the sixth chapter is a mixture of prose sentences and metrical verses. As Table 5 indicates, Mullā Farīd's Persian passages are written entirely in prose while the Sanskrit text includes eleven passages in metre [1–3, α–δ, and 8–11] and four passages in prose [4–7]. The metrical verses are numbered while the prose passages are are not.[43] These poetic verses are composed in a range Sanskrit metres:

1. Passages [2, 8]: eight-syllabled *pramāṇikā*
2. Passage [3]: eight-syllabled *anuṣṭubh*
3. Passage [9, 10]: eleven-syllabled *rathoddhatā*
4. Passages [1, 11]: twelve-syllabled *vaṃśasthavila*
5. Passages [β, γ]: twelve-syllabled *drutavilambita*
6. Passage [α]: seventeen-syllabled *pṛthvī*
7. Passage [δ]: *āryā jāti*-metre

The *Siddhāntasindhu* is the first explicit translation of an Islamicate astronomical text to use metrical Sanskrit (see remark on the style of composition on page 50). Its intention to Sanskritise the content for local *jyotiṣī*s may explain the use of metrical verses; however, it is not entirely clear why Nityānanda chooses to then translate certain Persian passages in prose. I list below my observations on these prose passages.

1. All three methods described in the text are prescriptive: they outline the constituent terms and then suggest a computational formula using these terms. There are no mathematical derivation or explanations given. The prose passages include an interpolative method of computation (in passage [4]) and three special cases (in passages [5–7]), both based on the formula of the second method (in passage [3]). They appear to illustrate the (use of the) formula rather than being ancillary to it.

43 The numbering scheme restarts at one for every metrical part following a prose interlude, see Remark in Table 3.

2. The interpolative method in passage [4], and again in passage [6], refers to the table of the Cosine of the greatest declination. MS Kh of the *Siddhāntasindhu* includes the text of these passages but not the table itself. In comparison, MSS $\mathrm{Sj_A}$ (f. 21b) and $\mathrm{Sj_B}$ (f. 16a) of the *Zīj-i Shāh Jahānī* present the table alongside the Persian text of the chapter.
3. The Sanskrit verses from the *Siddhāntasindhu* Part II.6 are also found in the *Sarvasiddhāntarāja*, *gaṇitādhyāya* 'chapter on computations'. Nityānanda copies these metrical verses verbatim into the *spaṣṭakrāntyādhikāra* 'section on true declination' of his *Sarvasiddhāntarāja* but leaves out the four prose passages from the *Siddhāntasindhu*. A critical edition and technical translation of the *spaṣṭakrāntyādhikāra* is to appear in Misra (forthcoming).

2.3.2 *Language of the text*

Nityānanda's Sanskrit passages of the sixth chapter follow Mullā Farīd's Persian text in more than their mathematical content. In the following remarks, I note some of the linguistic features of Nityānanda's compositions in comparison to Mullā Farīd's Persian sentences. All grammatical terms are abbreviated in these remarks, with an expanded list of abbreviations included on page 114.

1. *Grammatical similarity*

   (a) *Subject-fronting* The inflected grammar of Sanskrit allows a flexible word-ordering in most prose sentences, and even more so, in metrical verses. Nityānanda utilises this syntactic freedom and composes some of his verses to resemble Mullā Farīd's Persian statements quite closely. For example, the Persian text in passage [1] is a typical conditional sentence where the subjects precede the conditional proposition, viz.

   $$\underbrace{[\text{Given}]\ \mathrm{X}\ \&\ \mathrm{Y}}_{\text{subject-fronted events}}\ :\ \underbrace{\text{if}\ \mathcal{C}\,(\mathrm{X},\mathrm{Y})}_{\text{if-clause}}\ \longrightarrow\ \underbrace{\text{then}\ \mathcal{A}_1\,(\mathrm{X},\mathrm{Y}),\ \text{else}\ \mathcal{A}_2\,(\mathrm{X},\mathrm{Y})}_{\text{then-clause}}$$

   where $\mathcal{C}\,(\mathrm{X},\mathrm{Y})$ is the condition involving events 'X' and 'Y' in the if-clause, $\mathcal{A}_1\,(\mathrm{X},\mathrm{Y})$ is the first action of the two events in the then-clause, and $\mathcal{A}_2\,(\mathrm{X},\mathrm{Y})$ is the second alternative action of the two events in the then-clause.

   Persian grammar specifies various kinds of conditional sentences, and accordingly, the verbs in the if-clause (protasis) are in different verbal moods, e.g., if the condition is a proposition to be fulfilled, like in passage [1], the verb in the protasis is in the subjunctive mood: باشند (*bāshand*) PRES-SBJV 'should be'. The consequent then-clause (apodosis) can chose between indicative or subjunctive moods of verbs according to the context of the sentence. Nityānanda's

Sanskrit verse in passage [1] mirrors this subject-fronted conditional construction with the verb in the protasis in the optative mood: भवेत् (*bhavet*) OPT-ACT 'should be' (conditional possibility). The apodosis that follows states the consequent actions as statements to be understood as implicit instructions, viz. then [we take/do] $\mathcal{A}_1$ (X, Y), otherwise [we take/do] $\mathcal{A}_2$ (X, Y).

(b) *Implied modality* The realis mood of a present indicative statement in Persian also implies an irrealis future potential. For example, passage [2] includes two statements in the following form:

First (instructive) statement $\xrightarrow[\text{consequence}]{\text{implied}}$ Second (declarative) statement.

The second (declarative) statement uses the verb بود (*buvad*) PRES-IND 'is' to indicate 'the result *is* [something]'; this, in effect, also convey the meaning 'the result *will be* [something]'. Nityānanda's Sanskrit translation of this passage retains the form, and uses the verb भवेत् (*bhavet*) OPT-ACT 'will be' (future probability) to indicate a similar meaning: 'the result *will be* [something]'.

2. *Semantic equivalents* Nityānanda translates Islamicate astronomical terms using equivalent Sanskrit expressions, some of which, are literal translations; for example,

- circle passing through the four poles دایرهٔ ماره باقطاب اربعه (*dāyiri-yi mārri bi aqṭāb-i arbaʿi*) as ध्रुव-चतुष्क-यात-वृत्त (*dhruva-catuṣka-yāta-vṛtta*)
- latitude of a celestial object عرض کوکب (*ʿarḍ-i kawkab*) as खगस्य बाण (*khagasya bāṇa*), or
- one direction یک جهت (*yik jahat*) as एक-दिश् (*eka-diś*).

In other instances, his translations use novel (seemingly, didactic) Sanskrit expressions to capture the implied mathematical meaning of Islamicate terms; for example,

- Cosine of the inverse declination of the degree of a celestial object جیب تمام میل منکوس درجه کوکب (*jayb-i tamām-i mayl-i mankūs-i daraji-yi kawkab*)[44] as day-Sine [of the longitude] increased by three zodiacal signs स-भ-त्रय-द्युजीवा (*sa-bha-traya-dyujīvā*),

44 The use of the term 'inverse declination' (*al-māyl al-maʿkūs*) to indicate the [first] declination of the ecliptic longitude of a celestial object increased by ninety first appears in the works of thirteenth-century Marāgha astronomers, e.g., *Zīj-i Ilkhānī* of al-Ṭūsī (Hamadani-Zadeh 1987: 188) or *Tāj al-Azyāj* of Muḥyī l-Dīn al-Maghribī (Dorce 2002–3: 196).

- distance of a celestial object from the 'circle passing through the four poles' **دایرهٔ ماره باقطاب اربعه** از کوکب بعد (*buᶜd-i kawkab az «dāyiri-yi mārri bi aqṭāb-i arbaᶜi»*) as congruent complementary arc **सदृश-कोटि** (*sadṛś-koṭi*),
- first arc اوّل قوس (*qaws-i avval*) as maximum latitude **पर-इषु** (*para-iṣu*), or
- second arc دوم قوس (*qaws-i duvum*) as maximum true declination **पर-स्फुट-अपम** (*para-sphuṭa-apama*).

3. *Hybrid translations* Certain Sanskrit words appear to be a mix of literal and figurative translations, e.g., the 'argument of the distance', understood as the arc of the great circle passing through the two ecliptic poles and a celestial object, and lying between a celestial object and the celestial equator, is called حصّهٔ بعد (*ḥiṣṣi-yi buᶜd*) 'share of the distance' in Persian. Nityānanda translates this Persian expression as **स्फुट-अपम-अंश** (*sphuṭa-apama-aṃśa*) 'share of true declination' in passage [1], but then goes on to translate it as **स्फुट-अपम-अङ्क** (*sphuṭa-apama-aṅka*) 'curve of the true declination' in subsequent passages [2–4].[45] The change from the semantic equivalent (*aṃśa* 'share') to the pragmatic (*aṅka* 'curve') can either be a simple (and serendipitous) artefact of the single manuscript witness, or it may be a more volitional change meant to emphasise the didactic meaning in using the word.
4. *Original expressions* As noted earlier, Nityānanda composes four passages [α–δ] in his Sanskrit text to explain the terms involved in the third computational method. These terms are not directly expressed in the Persian text, and hence, Nityānanda's expressions are original in their language and their substance. For example, passage [α] defines the circle congruent to the ecliptic **भचक्र-सदृश-वृत्त** (*bhacakra-sadṛśa-vṛtta*), a great circle passing through the two equinoctial points and a celestial object, and resembling the ecliptic. For planetary objects, this is the orbit of the planet with the longitude of its node being zero; or as Nityānanda later indicates in passage [γ], when the conjunction of the equinoctial point and the node of the orbit of a celestial object **विषुव-पात-युग** (*viṣuva-pāta-yuga*) is being assumed.
5. *Synonymy and ambiguity* In rendering Mullā Farīd's Persian sentences into Sanskrit, Nityānanda employs a variety of Sanskrit synonyms (or near-synonyms) to translate Persian technical terms. For example, a celestial

45 Typically, the word **अङ्क** (*aṅka*) refers to a 'digit/number', or more literally, a 'mark/sign'. Nityānanda uses the word to signify a geometrical 'arc' or 'curve' of a great circle. There are several geometrical explanations in the *Siddhāntasindhu* as well as the *Sarvasiddhāntarāja* that validate the interpretation of the word *aṅka* as 'arc/curve' (e.g., see Misra 2016: 279).

object is called كوكب (*kawkab*) in Persian, whereas Nityānanda variously uses the words **खग** (*khaga*), **ग्रह** (*graha*), **द्युचर** (*dyucara*), **नक्षत्र** (*nakṣatra*), **नभोग** (*nabhoga*), and **भ** (*bha*) to describe such an object. The abundance of Sanskrit synonyms allows him to choose words that suits the metre of his verse; however, the metrical constraints also makes his translations a little vague in some instances. For example, the Persian text in passage [1] refers to the جهت حصّهٔ بعد (*jahat-i ḥiṣṣi-yi buᶜd*) 'direction of the share of the distance' as being in the جهت مجموع (*jahat-i majmūᶜ*) 'direction of the sum' or the جهت فضل (*jahat-i faḍla*) 'direction of the difference/residue'; in other words, dependant on the directions of the two quantities that make up the 'share of the distance'. In his Sanskrit translation in passage [1], Nityānanda simply states that the 'share of the true declination' is in its **स्व-दिश्** (*sva-diś*) 'own direction'.

6. *Lowering a sexagesimal number* Of particular note is an Islamicate arithmetic operation that, to my knowledge, does appear in any Sanskrit astronomical or mathematical text till the *Siddhāntasindhu*.
   Islamicate texts often include the operation منحطّ *munḥaṭṭ* 'lowering' a sexagesimal number before multiplying (low-multiplication) or before dividing (low-division). In effect, shifting the fractional point leftwards to *lower* the value of the sexagesimal number before operating on it; or in other words, dividing a number by the Radius (*sinus totus*) of 60.[46] Nityānanda uses the verb √**अधरी-कृ** (√*adharī-kṛ*) 'to make [something] low' or 'lower' to indicate a division by 60.[47] His translation of the term is more literal compared to later authors like Nayanasukhopādhyāya who, in his *Śarahatajkirā Virajandī* (1729), translates *munḥaṭṭ* from Niẓām al-Dīn al-Bīrjandī's *Sharḥ al-Tadhkira* (1507) as *ṣaṣṭyāpta*/*ṣaṣṭibhakta* 'divided by sixty' (Kusuba and Pingree 2001: 265).

2.4 GRAMMATICAL NOTES ON TRANSLATION

In translating the Persian text from Mullā Farīd's *Zīj-i Shāh Jahānī* Discourse II.6 and Nityānanda's *Siddhāntasindhu* Part II.6 into English, I have interpreted the verbs (and verbal derivatives) based on their implied modality in

46 For instance, al-Kāshī uses the word *munḥaṭṭ* 'to depress' a sexagesimal number, i.e., divide it by the Radius of 60, in relation to his Sine computations in his *Zīj al-Khāqānī* (*c*.1413/1414) (Hamadani-Zadeh 1980: 40).

47 MS Benares (1963) 37079 of the *Sarvasiddhāntarāja* from the Sarasvatī Bhavana Granthālaya (Varanasi) parses the word **अधर** *adhara* in relation to the divisor (in the last pāda of verse 6) as **अधर-सषष्टि-भक्त-भाजक-भजनं अत्र-अधर-भजन-संज्ञं उच्यते ।** (f. 63r: 11) '*adhara* is the sixtieth part [lit. with sixty divided] of the divisor of the division; here it is referred to as the *adhara*-division by name.'

the sentence. Hence, a particular form of a verb (e.g., an optative active in Sanskrit) is sometimes translated differently in different sentences. I list below some of the main aspects of my translations.

Persian to English

1. The Persian subjunctive mood expresses a variety of meanings based on the context of the sentence. Mullā Farīd's Persian text of the sixth chapter uses the present subjunctive form of verbs quite commonly. Translating these verbs using English indicative forms does not fully capture the subjunctive mood of the original sentences. Hence, I translate the Persian subjunctive verbs in my English translations with the modal verb 'should', e.g., باشد (*bāshad*) PRES-SBJV-SING·3rd '[he/she/it] should be' instead of '[he/she/it] is' or '[he/she/it] is to be'. This helps distinguish between the Persian indicatives (realis) and subjunctives (irrealis) in the passages, particularly, in the case of conditional clauses.
2. An impersonal passive sentence may be constructed in Persian with a third-person plural conjugation of the verb and a dismissive (or vague) subject. For example, the Persian text in passage [4] uses the verbs درآرند (*dar ārand*) PRES-IND-PL·3rd '[they] extract', along with a direct object (identified by the را (*rā*) marker) and no specific subject. The only indication of the subject is found in the enclitic conjugation of the verb. A syntax-preserving translation of this sentence reads 'they extract [the object]'; however, it can also be understood as the impersonal passive sentence '[the object] is extracted'. As grammatical opinions on passive constructions in Persian vary (e.g., see Nemati 2013: 261–264), I choose to retain the syntax-preserving form in my English translation in passage [4].

Sanskrit to English

1. The subjunctive mood is obsolete in classical Sanskrit and is replaced by the use of the optative. Like the subjunctive, the optative mood also indicates various meanings depending on the context of the verb. Nityānanda's Sanskrit passages from the sixth chapter use several verbs in their optative active form. I translate these forms according to their syntactic location (i.e., whether they occur in principal realis sentences or subordinating irrealis clauses) and their modal intention. For example, as I previously alluded in remarks 1a and 1b in § 2.3.2, the verb भवेत् (*bhavet*) OPT-ACT-SING·3rd implies both '[he/she/it] should be' (in conditional clauses) and '[he/she/it] will be' (in potential statements) depending on the context.

2. More generally, I use the the English modal verb 'should' to translate most Sanskrit optative forms to distinguish them from the indicative forms in English e.g., स्यात् (*syāt*) OPT-ACT-SING·3rd '[he/she/it] should be/exist' instead of '[he/she/it] is/exists'. In such translations, the English modal verb 'should' is more epistemic than deontic in conveying the irrealis mood (in other words, *should* conveys the sentiment of possibility or inference and not a directive or exhortation). Also, the use 'should' to mark the Persian subjunctive and the Sanskrit optative in the English translations reveal a syntactic similarity in the Persian and Sanskrit passages of the sixth chapter.

A complete list of the Persian verbs in the *Zīj-i Shāh Jahānī* Discourse II.6 and the Sanskrit verbs (and verbal derivatives) in *Siddhāntasindhu* Part II.6 can be found in Appendices B.1 and B.2 respectively.

3 EDITORIAL NOTES

I DISCUSS BELOW the orthographic standards and transcription/transliteration schemes I have adopted in editing the Persian text (from Sj_A & Sj_B) and the Sanskrit text (from Kh) in §§ 3.1–3.3. A description of the typographic conventions in §§ 4, 5, and 6 of this study follows that in § 3.4. Therein, I explain with examples the various symbols and abbreviations used in the critical footnotes of these sections. Lastly, § 3.5 describes the format of the Glossary (on page 115) and the Appendix B (on page 111).

3.1 REMARKS ON PERSIAN ORTHOGRAPHY

The Persian text presented in this study follows the orthography of Classical Persian in which the manuscripts were written. It does, however, use modern punctuation marks for added clarity.

Arabic loanwords are transcribed with their original spelling when they are attested as such, e.g., the Arabic letter ي (*yāʿ*) is retained in the spelling of the word ثاني (*thānī*) following Sj_A (f. 21b: 21). In other instances, Persian spellings are used, e.g., درجه (*daraji*) instead of the Arabic درجة with the Arabic letter ـة (*tāʾ-marbūṭah*). Persian words are presented in their unligated forms: e.g., آنرا on f.21b: 23 Sj_A is transcribed as آن را.

A few minor orthographic irregularities are seen in the Persian text of Sj_A and Sj_B. I note these below and emend them silently. However, when the reading of the text is affected by a grammatical ambiguity, I discuss my interpretation in corresponding footnotes. Scribal alterations, cancellations, copying errors, and marginalia are also noted in the footnotes.

1. Vocalisation marks are often omitted, in particular, on the syllable-initial آ (*alif madda*). For example, آن (*ān*) is simply written as ان on f. 22a: 2 Sj_A and f. 16b: 1 Sj_B.
2. Arabic loan words are generally written without any diacritics. For example, the words معدّل (*muʿaddil*) (on f. 21b: 21 Sj_A) and اوّل (*avval*) (on f. 14a: 1 Sj_B) are written without the over-letter diacritic ّ (*shadda/tashdīd*). Sj_A sometimes uses supplementary diacritics (*tashkīl*) to differentiate homographic words, e.g., on f. 22a: 8, the word دور, understood as 'distant/remote', is explicitly written as دُور (*dūr*, IPA /duːr/) with the over-letter diacritic ُ (*ḍamma/pish*) to differentiate it from دَور (*dawr*, IPA /dawr/) 'cycle/revolution'.
3. Sj_A also has occasional diacritic points that are misplaced, for instance, the word جهت (*jahat*) is spelt as جـهـت on f. 21b: 23. The overdot over the word-initial letter جـ (*jim*) is meaningless.

4. Sj_B sometimes lacks diacritic points to indicate the phonetic distinction of consonants (*iʾjām*). For example, the word-initial letter بـ (*be*) in بر (*bar*) appears without the underdot (on f. 16a: 30 Sj_B).

3.2 REMARKS ON SANSKRIT ORTHOGRAPHY

The Sanskrit text of Kh is fairly regular with occasional orthographic irregularities. Most of these are common scribal oversights seen in Nāgarī palaeography, and hence, I emend these silently. They include

1. using the over-letter diacritic ◌ं (*anusvāra*) for all conjoined nasal consonants;
2. omitting the diacritical marks ◌ः (*visarga*) for the terminal aspirate, ◌् (*virāma*) for inherent-vowel suppression, and ऽ (*avagraha*) for prodelision of *a*/*ā*;
3. using/omitting punctuation marks like the ॥ (*double-daṇḍa*) irregularly;
4. using irregular (vernacular?) Nāgarī letters (e.g., य़ for य) for Sanskrit, and retaining ill-formed vocalic signs (e.g., र्दी);
5. using doubled consonant irregularly, e.g., द्ध in अर्द्ध (after a vowel-suppressed *r*-consonant) or across line (*pāda*) breaks in a stanza;
6. reversing conjunct-consonant pairs (e.g., ध्व for ब्ध or न्ह for ह्न); and
7. confusing consonants like ब and व, प and य, म and स, ष and ख, etc., and certain ligatures like ष्ट for ष्ठ, क्त for त्क, etc.

However, I discuss in footnotes the structure of those orthographic irregularities (mainly, morphosyntactic errors) that affect the reading of the text even as I emend the words accordingly. Other scribal errors like haplography (inadvertent omission) and dittography (inadvertent repetition) are also described in footnotes.

3.3 TRANSCRIPTION AND TRANSLITERATION SCHEMES

I adopt the following transcription/transliteration schemes to render Arabic, Persian, Sanskrit, and Hindi characters into the Roman (Latin) script.

- Arabic and Persian texts are transcribed with the EI3 standard of phonetic transcription in Brill's *Encyclopedia of Islam*, third edition (Fleet et al. 2007–20).
- Sanskrit and Hindi texts are transliterated following the International Alphabet of Sanskrit Transliteration (IAST) scheme. For vernacular Hindi words, as well as Devanāgarī-spellings of transliterated Persian words, I

use the International Organisation for Standardisation (ISO) 15919 extension to transliterate certain characters, e.g., ड़ी is rendered as *ṛī*, खाँ as *khām̐*, etc. Commonly attested words of Indian origin (e.g., Hindu, Brahmin, Mughal, Varanasi, etc.) are presented without diacritics.

3.4 TYPOGRAPHIC CONVENTIONS

3.4.1 *Chapter-titles in § 4*

1. *Layout* The chapter-titles from Discourse II (*maqāla-i duvum*) of the *Zīj-i Shāh Jahānī* and Part II (*dvitīya-kāṇḍa*) of the *Siddhāntasindhu* are placed in parallel columns in § 4. The Persian title-text (to the left) and the Sanskrit title-text (to the right) can be identified by their corresponding chapter numbers in the left and right margins respectively, e.g., 'Disc II.2' (in the left margin; 'Discourse' abbreviated to 'Disc.') and 'Part II.2' (in the right margin) corresponding to the second chapter at the top of page 74. I include the folia and line numbers of the manuscripts at the end of the text in parentheses.
2. *Format of the translations* My English translations of the chapter-titles are placed right below the corresponding Persian and Sanskrit text, parallel to each other. The technical terms in the translations are typeset in bold, and are accompanied by a Roman transcription/transliteration (in parentheses) of corresponding Persian and Sanskrit expressions. I indicate any additional words/expressions supplied for grammatical clarity by enclosing them in square brackets '[ ]' in my translations.

3.4.2 *Chapter VI in §§ 5 & 6*

1. *Layout* The Persian and Sanskrit text of the sixth chapter from Discourse II of the *Zīj-i Shāh Jahānī* and from Part II of the *Siddhāntasindhu* are presented in § 5 and § 6 respectively. In both these sections, I place corresponding passages from the original text and their English translations on successive pages; see § 2.3.1 for my division of the text into comparable passages.
2. *Ordering of the passages* The passage-markers are enclosed in square brackets, e.g., '[2]' or '[α]', and placed at the beginning of the passages. They appear in the right margin for the Persian text, and in the left margin for the Sanskrit text and English translations.
3. *Roman transcription/transliteration* The technical expressions in the English translations are typeset in bold, and are accompanied by a Roman transcription/transliteration (in parentheses) of corresponding Persian and Sanskrit expressions. The Roman transcriptions of Persian compound verbs that indicate arithmetic operations are indicated in their infinitive form and are prefixed with an asterisk. For example, sum (**jam^c kardan*)

'to sum' in passage [1] on page 86. See footnote 3 in the Appendix B (on page 111).

4. *Verse numbering in § 6* The numbering of the metrical Sanskrit verses is *different* from the ordering of the passages. I follow the Sanskrit text in placing the verse numbers at the end of the stanzas in my translations. For instance, the verse-number '॥ १ ॥' at the end of a stanza in passage [α] (on page 93) also appears as '1' at the end of my English translation (on page 94).
5. *Poetic meters in § 6* The Sanskrit names of the poetic meters are indicated (in Roman transliteration) in the right margin alongside the Sanskrit verses, e.g., verse number '॥ २ ॥' (in passage [2]) is in the *pramāṇikā*-meter indicated in the right margin margin (in-line with the verse) on page 91.
6. *Folio breaks*
   - For the Persian text in § 5, I indicate a folio break with '⌉' (in-line with the text) and state the manuscript reference in the left margin. For instance, passage [2] on page 85 has '...بعد⌉ جیب...' on its second line and corresponding to it, 'f. 22a: 1 Sj_A ⌉' is written in the left margin. This indicates the words '...بعد' begin on line 1 of f. 22a in Sj_A.
   - For the Sanskrit text in § 6, folio breaks are shown with '⌈' (in-line with the text) and manuscript references are in the right margin. For instance, the first line of passage [β] on page 95 has '...विवर⌈गं धनु...', and correspondingly, '⌈ f. 20v: 1 Kh' is in the right margin. This implies the words 'गं धनु...' begin on line 1 of f.20v in Kh.

3.4.3 *Critical footnotes in §§ 4, 5, & 6*

1. Footnotes in § 4 are numbered 1, 2, 3 etc., whereas, those in §§ 5 & 6 are numbered [i], [ii], [iii] etc. The numbers are reset at the beginning of each section.
2. I use repeated footnote marks for longer footnotes in the Persian text (in § 5), e.g., footnote '[vi]—[vi]' on page 87 where '[vi]–' and '–[vi]' enclose the commented text in passage [9].
3. An edited reading is separated from a variant (attested) reading by a right square bracket ⌋ like, for instance, नाम मध्याह्नरेखेति ⌋ नाम ध्याह्नरेखेति Kh (footnote 6 on page 80) or در یا ⌋ در یاد Sj_B (footnote [iii] on page 87).
4. I use abbreviated forms of grammatical terms in the critical footnotes. For example, the MOD (modifier) प्रथम in the nominal compound प्रथमाध्याये is indicated as प्रथम$_{\text{MOD}}$ in footnote 1 on page 73. An expanded list of all grammatical abbreviations used in this study can be found on page 114.

5. The truncation (of letters) in long Sanskrit words is indicated by the Nāgarī abbreviation symbol '०' (*lāghava-cihna*), comparable in its use to an ellipsis. For example, गणित० for गणितसौकर्यार्थं or ०मांशाख्य for स्फुटापमांशाख्य.
6. I emphasise the letters in Persian and Sanskrit words by underlying them, e.g., قسمت or उन्नत. The emphasis is used in the critical footnotes to signify an orthographic feature or a scribal error that is overt.

3.5 FORMAT OF APPENDIX B AND THE GLOSSARY

All Persian and Sanskrit words in Appendix B and the glossary are written with Perso-Arabic and Nāgarī letters respectively, and are accompanied by corresponding Roman transcriptions/transliterations enclosed in parentheses. The grammatical terms are abbreviated in Appendix B and the glossary; their expanded forms are listed on page 114.

Appendix

Appendix B includes a list of the Persian and Sanskrit verbs seen in the *Zīj-i Shāh Jahānī* Discourse II.6 and the *Siddhāntasindhu* Part II.6 respectively.

- The Persian verbs are listed on page 111 in their infinitive form along with their corresponding present stems. I group together the attested (inflected) forms of these verbs and provide *passage-markers* (in square brackets at the end) to locate them in the text in § 5. For example,

  باشد (*bāshad*) PRES-SBJV-SING·3rd '[he/she/it] should be' [1, 3–8, 10, 11].

- The Sanskrit verbs are indicated in their root-form beginning on page 112. The verbal roots (of different verb-class numbers) are grouped together based on their common meaning. The attested (inflected forms) are listed under their respective verbal root, and are accompanied by *passage-markers* (in square brackets at the end) to locate them in the text in § 6. For example,

  स्यात् (*syāt*) OPT-ACT-SING·3rd '[he/she/it] should be/exist' [3–7].

Glossary

Persian and Sanskrit technical expressions are listed in the glossary (beginning on page 114). They are derived from §§ 4, 5, and 6 where they appear as highlighted entries in corresponding English translations.

- Equivalent Persian and Sanskrit terms are grouped together under their common technical translation in English, separated from each other by a semicolon. Synonyms are separated by commas. For example,

latitude عرض (*ʿarḍ*) [5, 6, 10]; शर (*śara*) [6], बाण (*bāṇa*) [10].

- At the end of each entry, I provide the *chapter-numbers* and/or the *passage-markers* in square brackets to identify its location in the text. The identifiers refer to apposite passages or chapter-titles corresponding to the language of the entry. For instance, in the example above, عرض (*ʿarḍ*) appears in passage [6] of § 5 (page 88); whereas, शर (*śara*) can be found in passage [6] of § 6 (page 94).
- References to multiple chapter-numbers are separated by commas (without repeating 'II'). For example,

  ascendant طالع (*ṭāliʿ*), pl. طوالع (*ṭawaliʿ*) II.11, 21, 22; लग्न (*lagna*) II.21

  indicates that طوالع (*ṭawaliʿ*) appears in the chapter-titles of the Persian chapters II.11, II.21, and II.22 in § 4.
- Successive chapter-numbers or passage-markers are sometimes shown as a range to save space, e.g.,

  definition लक्षण (*lakṣaṇa*) II.2, 8–13, 17–19, 22.
- Mutually related technical translations in English are grouped together based on their linguistic or mathematical similarity. For instance, the heading distance from the celestial equator or true declination— (on page 119) includes the expressions ↪ distance, ↪ distance of a celestial object from the celestial equator, and ↪ true declination.
- The glossary entries are arranged following the English alphabetical order.

4 CHAPTER-TITLES FROM THE *ZĪJ-I SHĀH JAHĀNĪ* DISCOURSE II AND THE *SIDDHĀNTASINDHU* PART II: TEXT AND TRANSLATION

Disc. II *incipit*

مقاله دوم
در معرفت اوقات و طالع هر وقت و آنچه تعلق بدان دارد مشتمل بر بیست و دو باب.
(f. 14a: 1 Sj_B)

Second Discourse
On the knowledge (*maᶜrifat*) of [finding] the times (*avqāt*) and the ascendant at each time (*ṭāliᶜ har vaqt*), and whatever belongs to it [i.e., all things related to this topic], including twenty-two chapters.

Part II *incipit*

नित्यानन्दस्वरूपाय सच्चिद्वयमुर्तये ॥
अद्वितीयाय विभवेऽनन्ताय ब्रह्मणे नमः ॥

अथ द्वितीयकाण्डे द्वाविंशत्यध्यायैरभिमत-समयस्तात्कालिकलग्नं च तदुपयोगीन्यपि ज्ञायन्ते ॥ (f. 17r: 1–3 Kh)

Obeisance to Brahman (*brahman*) who is the embodiment of eternal bliss (*nitya-ānanda-svarūpa*), who is the form of both existence and thought (*sat-cit-dvaya-mūrti*), who is [the One] without a second (*advitīya*), who is omnipresent (*vibhū*), [and] who is infinite (*ananta*).

Now, in the second part, [finding] the desired time (*abhimata-samaya*) and the ascendant at that time (*tātkālika-lagna*), as well as [things] using that, are understood with twenty-two chapters.

Disc. II.1

باب اوّل

در بیان معرفت جنس هر یک از حاصل ضرب و خارج قسمت و جذر، یعنی دانستن آنکه حاصل ضرب یا خارج قسمت یا جذر از کدام مرتبه است از مراتب مرفوعات و درج و اجزاء درج مثل دقایق و ثواني و غیر آن. (f. 14a: 3–1 Sj_B)

First Chapter

On the expression of the knowledge (*maʿrifat*) of each genus (*jins*) [of digits] from the result of multiplication (*ḥāṣil-i ḍarb*), and the quotient of division (*khārij-i qismat*), and the square root (*jaḏr*). In other words, to know what is the position (*martaba*) of [the digits in] the result of multiplication (*ḥāṣil-i ḍarb*), or the quotient of division (*khārij-i qismat*), or the square root (*jaḏr*), from the positions (*marātib*) of elevated [ranks] (*marfūʿāt*) [sc. integer number of revolutions], and the degree (*daraj*), and the fractional parts of a degree (*ajzāʾ-i daraj*) like minutes (*daqāʾiq*) and seconds (*thawānī*) and so on.

Part II.1

तत्र प्रथमाध्याये[1] गुणनभजनफले मूलं च परिवर्तादिस्थानैः कलादि स्थानैर्वा किं जातीयं स्यादिति ज्ञायते ॥ तत्र गणितसौकर्यार्थं[2] यवन-प्रसिद्धप्रकारेणाङ्कस्थानानां संस्कृतशब्दैः संज्ञा कल्प्यते ॥ (f. 17r: 3–5 Kh)

There, in the first chapter, with [digits in] the positions (*sthāna*) of revolution (*parivarta*) etc. or with [digits in] the positions (*sthāna*) of minute (*kalā*) etc. in the result of multiplication and division (*guṇana-bhajana-phala*), and the square root (*mūla*), what [digits] should belong to a particular genus (*jātīya*): this is understood. Therein, for the purpose of facilitating ease in computations (*gaṇita-saukarya-artha*) with the method famous amongst the foreigner (*yavana-prasiddha*), the name of the positions (*sthāna*) of digits (*aṅka*) is considered with Sanskrit words.

1 प्रथमाध्याये] प्रथमध्याये Kh. A regular sandhi of the words प्रथम $_{\text{MOD}}$ + अध्याये $_{\text{LOC-SING}}$ generates the compound प्रथमाध्याये. The omission of the long vowel (*ā*-diacritic in मा looks like a scribal oversight.

2 गणित०] गणीत० Kh. There are no morphological divisions of गणीत that are syntactically admissible in the larger compound गणीतसौकर्यार्थं, whereas the word गणित is both grammatically well-formed and contextually apposite. I suspect the use of the long vowel (the *ī*-diacritic in णी) is either a scribal hypercorrection or an inadvertent misspelling.

Disc. II.2

باب دوم
در عمل تعدیل ما بین السطرین.
(f. 14b 6 Sj_B)

Second chapter
On the method of interpolation (*ʿamal-i taʿdīl*) between two lines (*mā bayn al-saṭrayn*) [of a table].

Part II.2

अथ द्वितीयाध्याये द्विकोष्ठान्तरोत्थफलसाधनम् ॥ तस्य मूलं त्रैराशिकम् ॥ अत्र यवनाः परस्परसम्बन्धिचतूराशीन्गणयन्ति ॥ तल्लक्षणं च ॥ (f. 18r: 2–4 Kh)

Now, in the second chapter, the demonstration (*sādhana*) of the result (*phala*) derived from the difference between two cells (*dvi-koṣṭha-antara*). The basis of this is the rule of three (*trai-rāśika*). Here, the foreigner (*yavana*) take into account four correlated numbers (*paraspara-sambandhi-rāśi*). And their definitions (*lakṣaṇa*) [are first stated].

Disc. II.3

باب سیوم
در معرفت جیب و سهم. (f. 15a: 8 Sj_B)

Third chapter
On the knowledge (*maʿrifat*) of the Sine (*jayb*) and the Sagitta (*sahm*) [i.e., the Versed Sine].

Part II.3

अथ तृतीयाध्याये ज्याशरज्ञानम् ॥ (f. 18r: 23–24 Kh)

Now, in the third chapter, the knowledge (*jñāna*) of the Sine (*jyā*) and the Versed Sine (*śara*).

Disc. II.4

باب چهارم
در معرفت ظلّ. (f. 15b: 1 Sj_B)

Fourth chapter
On the knowledge (*maʿrifat*) of the shadow (*ẓill*) [of a gnomon].

Part II.4

अथ चतुर्थाध्याये छायाज्ञानम् ॥ (f. 19r: 13 Kh)

Now, in the fourth chapter, the knowledge (*jñāna*) of the shadow (*chāyā*) [of a gnomon].

Disc. II.5

باب پنجم
در معرفت میل اجزاء فلك البروج از معدّل النهار. (f. 16a: 4 Sj_B)

Fifth chapter
On the knowledge (*maᶜrifat*) of the declination of parts of the ecliptic (*mayl-i ajzāʾ-i falak al-burūj*) from the celestial equator (*muᶜaddil al-nahār*).

Part II.5

अथ पञ्चमाध्याये क्रान्तिज्ञानम् ॥ तत्र तावत्क्रान्तिसूत्रादिसंज्ञोच्यते ॥ (f. 19v: 18–19 Kh)

Now, in the fifth chapter, the knowledge (*jñāna*) of the declination (*krānti*). There, firstly, a [technical] term beginning with circle of declination (*krānti-sūtra*) is stated.

Disc. II.6

باب ششم
در معرفت بعد کواکب از معدّل النهار. (f. 16a: 26–25 Sj_B)

On the knowledge (*maᶜrifat*) of the distance of a celestial object from the celestial equator (*buᶜd-i kawākib az muᶜaddil al-nahār*).

Part II.6

अथ षष्ठाध्यायस्पष्टक्रान्तिज्ञानम् ॥ (f. 20r: 16 Kh)

Sixth chapter
Now, the knowledge (*jñāna*) of the true declination (*spaṣṭa-krānti*) in the sixth chapter.

Disc. II.7

باب هفتم
در معرفت غایت ارتفاع و انخفاض کواکب. (f. 16b: 11–10 Sj_B)

Seventh chapter
On the knowledge (*maᶜrifat*) of the maximum elevation and depression of a celestial object (*ghāyat-i ʾirtifāᶜ va inkhifāḍ-i kawākib*).

Part II.7

अथ सप्तमाध्याये ग्रहस्य परमोन्नतांशानामधःस्थपरमभागानां च ज्ञानम् ॥ (f. 20v: 12–13 Kh)

Now, in the seventh chapter, the knowledge (*jñāna*) of the degrees of the maximum elevation (*parama-unnata-aṃśa*) and the degrees of the maximum depression (*adhaḥstha-parama-bhāga*) of a celestial object (*graha*).

Disc. II.8

باب هشتم
در معرفت مطالع خطّ استوا و آنرا مطالع فلك مستقيم نيز گويند. (f. 16b: 17 Sj_B)

Eighth chapter
On the knowledge (*maᶜrifat*) of ascensions [of the ecliptic] at the line of the terrestrial equator (*maṭāliᶜ khaṭṭ-i istiva*) [i.e., the right ascensions of the zodiacal signs]. And that is also called the ascensions [of the ecliptic] in the right sphere (*maṭāliᶜ falak-i mustaqīm*).

Part II.8

अथ अष्टमाध्याये व्यक्षोयांशज्ञानम् ॥ तेषां लङ्कोदयांशसंज्ञाप्युच्यते ॥ तल्लक्षणमाह ॥ (f. 20v: 24–25 Kh)

Now, in the eighth chapter, the knowledge (*jñāna*) of the rising [of the zodiacal signs] at the terrestrial equator in degrees (*vyakṣa-udaya-aṃśa*) [i.e., the right ascensions of the degrees of the ecliptic]. All of them are also called the rising [of the zodiacal signs] at Laṅkā in degrees (*laṅkā-udaya-aṃśa*) by name. Their definitions (*lakṣaṇa*) state [as follows].

Disc. II.9

باب نهم
در معرفت تعديل النهار و قوس النهار و قوس الليل و ساعات النهار و ساعات الليل. (f. 16b: 25 Sj_B)

Ninth chapter
On the knowledge (*maᶜrifat*) of the equation of daylight (*taᶜdīl al-nahār*); and the arc of daylight (*qaws al-nahār*) and the arc of night (*qaws al-layl*); and the hours of daylight (*sāᶜāt al-nahār*) and hours of night (*sāᶜāt al-layl*).

Part II.9

अथ नवमाध्याये चरदिनरात्रिवामानां दिनरात्रिहोरादीनां च ज्ञानम् ॥ तत्र तावत्तेषां लक्षणम् ॥ (f. 21r: 5–6 Kh)

Now, in the ninth chapter, the knowledge (*jñāna*) of the ascensional difference (*cara*) of the oblique diurnal circle (*dina-rātri-vāma*[*-vrtta*]) and of the hours of day and night (*dina-rātri-horā*) etc. There, firstly, the definitions (*lakṣaṇa*) of those [are stated].

Disc. II.10

باب دهم
در معرفت مطالع بلد. (f. 17a 26 Sj_B)

Tenth chapter
On the knowledge (*maᶜrifat*) of the ascensions [of the ecliptic] of a locality (*maṭāliᶜ-i balad*) [i.e., the oblique ascensions of the zodiacal signs].

Part II.10

अथ दशमाध्याये निजोदयांशज्ञानम् ॥ तल्लक्षणं च ॥ (f. 21v: 23 Kh)

Now, in the tenth chapter, the knowledge (*jñāna*) of the rising [of the zodiacal signs] in one's own location in degrees (*nija-udaya-aṃśa*) [i.e., the oblique ascensions of the degrees of the ecliptic]. And their definitions (*lakṣaṇa*) [are first stated].

Disc. II.11

باب یازدهم
در عمل عکس مطالع یعنی معرفت طوالع از مطالع[3] بعمل. (f. 17b: 5 Sj_B)

Part II.11

अथैकादशाध्याये स्वोदयांशेभ्यो विनैव कोष्टकैर्विलोमक्रियातो विलग्नांशकज्ञानम्॥ विलोमक्रियालक्षणम् ॥ (f. 22r: 9–11 Kh)

Eleventh chapter
On the inverse method (*ʿamal-i ʿaks*) [of] ascensions (*maṭāliʿ*); in other words, the knowledge of the [ecliptic degrees of the] ascendants (*ṭawaliʿ*) from the [local] ascensions (*maṭāliʿ*) [i.e., from the oblique ascensions of the ascendants] by direct calculation.

Now, in the eleventh chapter, the knowledge (*jñāna*) of the [ecliptic] degrees of the ascendants (*vilagna-aṃśaka*) from the rising [of the zodiacal signs] in one's own location in degrees (*sva-udaya-aṃśa*) [i.e., from the oblique ascensions of the ascendants] without [using] the tables (*koṣṭhaka*) [and] by using the inverse procedure (*viloma-kriyā*). The definition (*lakṣaṇa*) of the inverse procedure (*viloma-kriyā*) [is first stated].

3 The words از مطالع are a marginal addition. They appears in the exterior (left) margin of f. 17a Sj_B alongside line 5 of the text. The main text has an interlinear insertion mark '٧' at the end of the preceding طوالع. The marginal text ends with a terminal *number-like* mark ۴ which, according to Gacek (2009: 117), is an abbreviation for تمام شد *tamām shud* 'ended/finished' often seen in manuscripts of Indian/Iranian origins.

Disc. II.12

باب دوازدهم
در معرفت مطالع ممرّ و درجهٔ ممرّ کوکب.
(f. 17b: 30–29 Sj_B)

Twelfth chapter
On the knowledge (*maᶜrifat*) of the ascensions of [the degrees] of [meridian] transit (*maṭāliᶜ-i mamarr*) [i.e., the right ascension of the zodiacal sign culminating with a celestial object] and the [ecliptic] degree of the [meridian] transit [at the time of rising] of a celestial object (*daraji-yi mamarr-i kawkab*) [i.e., the ecliptic longitude of the zodiacal sign culminating with a celestial object].

Part II.12

अथ द्वादशाध्याये नक्षत्रस्य लङ्कायामुदये जाते सति भोदयलग्नव्यक्षोदयांशभोदयलग्नांशयोर्ज्ञानम् ॥ तल्लक्षणम् ॥ (f. 22v: 15–17 Kh)

Now, in the twelfth chapter, when a celestial object (*nakṣatra*) rises (*udaya*) at Laṅkā (the terrestrial equator), the knowledge (*jñāna*) of the degrees of equatorial ascension of the [meridian] ecliptic point at the [time of] rising of a celestial object (*bha-udaya-lagna-vyakṣa-udaya-aṃśa*) [i.e., the right ascension of the zodiacal sign culminating with the celestial object] and the degrees of the [meridian] ecliptic point at the [time of] rising of a celestial object (*bha-udaya-lagna-aṃśa*) [i.e., the ecliptic longitude of the zodiacal sign culminating with the celestial object]. Their definitions (*lakṣaṇa*) [are first stated].

Disc. II.13

باب سیزدهم
در مطالع طالع و غروب کواکب.
(f. 18a: 12–11 Sj_B)

Thirteenth chapter
On the [right] ascensions (*maṭāli*^{c}) of the rising (*ṭāli*^{c}) and setting (*ghurūb*) of celestial objects (*kawākib*).

Part II.13

अथ त्रयोदशाध्याये नक्षत्रस्योदयसमये ऽस्तसमये च निजोदयांशकज्ञानम् ॥ तल्लक्षणं पूर्वार्धमध्ये[4] प्रोक्तमेव ॥ (f. 23r: 6–7 Kh)

Now, in the thirteenth chapter, at the time of rising (*udaya-samaya*) and time of setting (*asta-samaya*) of a celestial object (*nakṣatra*), the knowledge (*jñāna*) of the rising [of the zodiacal signs] in one's own location in degrees (*nija-udaya-aṃśaka*) [i.e., the oblique ascensions of the degrees of the ecliptic]. The definition (*lakṣaṇa*) of that has already been declared in the first half [of Part II].

Disc. II.14

باب چهاردهم
در معرفت سمت از ارتفاع یا انخفاض.
(f. 18a: 20 Sj_B)

Fourteenth chapter
On the knowledge (*ma*^{c}*rifat*) of the azimuth (*samt*) from the elevation (*ʾirtifā*^{c}) or the depression (*inkhifāḍ*) [of a celestial object].

Part II.14

अथ चतुर्दशाध्याये ऽभीप्सितोन्नतांशाधरांशेभ्यः[5] स्वदिग्गंशज्ञानम् ॥ (f. 23r: 24 Kh)

Now, in the fourteenth chapter, the knowledge (*jñāna*) of the degrees of azimuth in one's own location (*sva-diś-aṃśa*) from the desired degrees of elevation (*abhīpsita-unnata-aṃśa*) and the degrees of depression (*adharā-aṃśa*) [of a celestial object].

4 पूर्वार्धमध्ये] पूर्वाधमये Kh. The compound पूर्वाधमये in Kh can be segmented as पूर्व$_{\text{MOD}}$ + अध$_{\text{MOD}}$ + मये$_{\text{LOC-SING}}$; however, this reading is neither syntactically nor contextually coherent with the rest of the sentence. The omission of over-letter *r*-diacritic (*repha*) in र्ध and confusing the glyph ये for the ligature ध्ये are fairly common scribal mistakes.

5 ऽभीप्सितोन्नतांशाधरांशेभ्यः] ऽभीप्सितोन्नतंशाधाराशेभ्य Kh. A regular sandhi of the words ऽभीप्सित$_{\text{MOD}}$ + उन्नत$_{\text{MOD}}$ + अंश$_{\text{MOD}}$ + अधर$_{\text{MOD}}$ + अंशेभ्यः$_{\text{DAT/ABL-PL}}$ generates the contextually apposite compound ऽभीप्सितोन्नतांशाधरांशेभ्यः. Kh attests आधार$_{\text{MOD}}$ 'support/base' instead of अधर$_{\text{MOD}}$ 'lower' in the chapter-title, but then uses अधर$_{\text{MOD}}$ in several other places in this chapter. I suspect the irregular vowel-marks (the *a*-diacritic in तं and *ā*-diacritic in धा) in ऽभीप्सितोन्नतंशाधाराशेभ्य are scribal mistakes (just like the missing *anusvāra* over रा or the missing *visarga* in भ्य).

Disc. II.15

باب پانزدهم
در معرفت ارتفاع از سمت.
(f. 18b: 8–7 Sj_B)

Fifteenth chapter
On the knowledge (*maᶜrifat*) of the elevation (*ʾirtifāᶜ*) [of a celestial object] from [its] azimuth (*samt*).

Part II.15

अथ पञ्चदशाध्याये दिगंशेभ्यो ऽभीष्टोन्नतांशाधरांशज्ञानम् ॥ तत्रानन्यत्वप्रकारोपपत्तिः ॥ (f. 23v: 21–22 Kh)

Now, in the fifteenth chapter, the knowledge (*jñāna*) of the desired degrees of elevation (*abhīṣṭa-unnata-aṃśa*) and the degrees of depression (*adharā-aṃśa*) [of a celestial object] from the degrees of azimuth in one's own location (*sva-diś-aṃśa*). There, a demonstration (*upapatti*) by method of identity (*ananyatva-prakāra*) [is stated].

Disc. II.16

باب شانزدهم
در معرفت خطّ نصف النهار.
(f. 18b: 16–15 Sj_B)

Sixteenth chapter
On the knowledge (*maᶜrifat*) of the line of midday (*khaṭṭ niṣf al-nahār*) [i.e., the local meridian line].

Part II.16

अथ षोडशाध्याये याम्योत्तररेखाज्ञानम् ॥ तस्य एव नाम मध्याह्नरेखेति[6] ॥ (f. 24r: 14–15 Kh)

Now, in the sixteenth chapter, the knowledge (*jñāna*) of the line of the meridian (*yāmya-uttara-rekhā*). It is even called the line of midday (*madhyāhna-rekhā*).

Disc. II.17

باب هفدهم
در معرفت طول و عرض بلد.
(f. 18b: 29 SjB)

Seventeenth chapter
On the knowledge (*maᶜrifat*) of the [terrestrial] longitude and latitude of a locality (*ṭūl va ᶜarḍ-i balad*).

Part II.17

अथ सप्तदशाध्याये देशान्तराक्षांशज्ञानम् ॥ तल्लक्षणं च ॥ (f. 24v: 4 Kh)

Now, in the seventeenth chapter, the knowledge (*jñāna*) of degrees of [terrestrial] longitude and latitude (*deśāntara-akṣa-aṃśa*) [in one's own location]. And their definitions (*lakṣaṇa*) [are first stated].

6 नाम मध्याह्नरेखेति] नाम ध्याह्नरेखेति Kh. The technical word मध्याह्नरेखा is grammatically well-formed and contextually apposite to the discussions in this chapter. The words नाम and ध्याह्नरेखेति occurs across a line break (lines 14 and 15) in Kh. This appears to be a haplography: the scribe inadvertently left out the second म while copying.

Disc. II.18

باب هژدهم
در معرفت عرض اقليم رؤيت.
(f. 19a: 20–19 SjB)

Eighteenth chapter
On the knowledge (*maᶜrifat*) of the latitude of the visible climate (*ᶜarḍ-i iqlīm-i ruʾyat*) [i.e., the zenith distance of the nonagesimal point].

Part II.18

अथाष्टादशाध्याये दृक्क्षेपदृग्गतिज्ञानम् ॥ तल्लक्षणं च ॥ (f. 25r: 12–13 Kh)

Now, in the eighteenth chapter, the knowledge (*jñāna*) of zenith distance of the nonagesimal point (*dṛkkṣepa*) and the zenith distance of the ecliptic pole (*drggati*). And their definitions (*lakṣaṇa*) [are first stated].

Disc. II.19

باب نوزدهم
در استخراج بعد ميان دو كوكب.
(f. 19a: 28 SjB)

Nineteenth chapter
On the determination (*istikhrāj*) of the distance between two celestial objects (*buᶜd-i miyān-i duvum-i kawkab*).

Part II.19

अथैकोनविंशाध्याये[7] द्विनक्षत्रान्तरांशकज्ञानम् ॥ तल्लक्षणम् ॥ (f. 25v: 6–7 Kh)

Now, in the nineteenth chapter, the knowledge (*jñāna*) of degrees [of separation] between two celestial objects (*dvi-nakṣatra-antara-aṃśaka*). The definition (*lakṣaṇa*) of that [is first stated].

7 अथैकोनविंशाध्याये] अथैकोनविंशोध्याये Kh. The locative adverbial phrase अथैकोनविंशोध्याये in Kh can be segmented as अथ$_{\text{INDECL}}$ + एकोनविंशः$_{\text{NOM-SING}}$ + अध्याये$_{\text{LOC-SING}}$. However, the word एकोनविंशः 'nineteen' is a cardinal number, and if used as an ordinal adjective, it should be in concord with the substantive अध्याये. The meaning of the phrase 'in the nineteenth chapter' is preserved in the compound एकोनविंशाध्याये as well as the words एकोनविंशे ऽध्याये (with a locative concord). I select the compounded form as it is consistent with the previous chapter-titles in Part II.

Disc. II.20

باب بیستم
در معرفت سمت قبله و انحراف او.
(f. 19b: 22–21 SjB)

Twentieth chapter
On the knowledge (*maᶜrifat*) of the azimuth of *qibla* (*samt-i qibla*) and its inclination (*inḥirāf* [*-i samt-i qibla*]).

Part II.20

अथ विंशतिमे ऽध्याये[8] स्वपुरे सौम्ययाम्यदिग्भ्यां दिगंशैः काशी कास्तीति[9] ज्ञायते ॥
(f. 26v: 17–18 Kh)

Now, in the twentieth chapter, [the direction of] Kāśī is understood with degree of azimuth (*diś-aṃśa*) [measured] from both the northern and southern directions (*saumya-yāmya-diś*) in one's own city.

Disc. II.21

باب بیست و یکم
در معرفت طالع از ارتفاع. (f. 20a: 31 SjB)

Twenty-first chapter
On the knowledge (*maᶜrifat*) of the ascendant (*ṭāliᶜ*) from the elevation (*ʾirtifāᶜ*).

Part II.21

अथ एकविंशतिमे ऽध्याये ऽभीष्टोन्नतांशेभ्यो[10] लग्नज्ञानम् ॥ (f. 27r: 26–27 Kh)

Now, in the twenty-first chapter, the knowledge (*jñāna*) of the ascendant (*lagna*) from the desired degrees of elevation (*abhīṣṭa-unnata-aṃśa*).

8 विंशतिमे ऽध्याये] विंशतिध्याये Kh. The attested form is morphologically defective. A regular sandhi of the words विंशति$_{\text{MOD}}$ + अध्याये$_{\text{LOC-SING}}$ generates विंशत्यध्याये, a locative adverbial phrase meaning 'in twenty chapters'. I correct this to विंशतिमे ऽध्याये 'in the twentieth chapter' (using the ordinal form विंशतिम 'twentieth' instead of the cardinal number विंशति 'twenty') as it is consistent with the next two chapter-titles in Part II.

9 काशी कास्तीति] काशीकाःमी/सीःति Kh, (*conjecture*). There are no visible signs of scribal corrections or lacunae, but the writing (in red ink) is partially faded making it difficult to identify the letters with certainty. Nevertheless, there are no combinations of these letters that provide a grammatically valid and contextually apposite reading. I emend the words to काशी कास्तीति, lit. the question "Where is Kāśī?", that serves as the subject of the main sentence. (In other words: "Where is Kāśī?", *this* is [understood with ...]). I suspect the scribe unwittingly copied the glyph मी/सी for the ligature स्ती as they often appear very similar in Nāgarī palaeography.

10 ऽभीष्टोन्नतांशेभ्यो] ऽभीष्टोन्नवांशेभ्यो Kh. The compound ऽभीष्टोन्नवांशेभ्यो in Kh can be segmented as ऽभीष्ट$_{\text{MOD}}$ + उन्नव$_{?}$ + अंशेभ्यो$_{\text{DAT/ABL-PL}}$; however, उन्नव is neither a valid morphophonemic compound nor a standard lexical entry. The word उन्नत is contextually relevant and also variously attested in this chapter, e.g., उन्नतज्यायाः (f. 27r: 27 Kh) or समुन्नतज्या (f. 27v: 14 Kh). I suspect the scribe inattentively copied the glyph वां for तां in the chapter-title.

Disc. II.22

باب بیست و دوم
در معرفت ارتفاع یا انخفاض کواکب از طالع. (f. 20b: 25–24 SjB)

Twenty-second chapter
On the knowledge (*maʿrifat*) of the elevation (*ʾirtifāʿ*) or depression (*inkhifāḍ*) of celestial objects (*kawākib*) from the ascendant (*ṭāliʿ*).

Part II.22

अथ द्वाविंशतिमे ऽध्याये खगस्य स्वोदयांशेभ्यो[11] ऽभीष्टोन्नतांशानामधरांशकानां च ज्ञानम् ॥ एतल्लक्षणं पूर्वमेषोक्तम् ॥ (f. 28r: 16–17 Kh)

Now, in the twenty-second chapter, the knowledge (*jñāna*) of the desired degrees of elevation (*abhīṣṭa-unnata-aṃśa*) and of the degrees of depression (*adhara-aṃśaka*) from the rising [of the zodiacal signs] in one's own location in degrees (*sva-udaya-aṃśa*) of a celestial object (*khaga*). The definition (*lakṣaṇa*) of this has already been declared in the first half [of Part II].

11 स्वोदयांशेभो] स्वोदयंशोभ्यो Kh. A regular sandhi of the words स्व$_{\text{MOD}}$ + उदय$_{\text{MOD}}$ + अंशेभ्यो$_{\text{DAT/ABL-PL}}$ generates स्वोदयांशेभ्यो where the terminal consonant -श (of अंश) changes to -शे (and not -शो) before the dative/ablative case ending -भ्यः. The *o*-diacritic in शो appears to be a scribal hypercorrection.

The *Zīj-i Shāh Jahānī*: Discourse II does not have a colophon. F 21r: 21 Sj_B ends with the last line of chapter twenty-two: بهین موامره همین مطلوب حاصل آید...

Part II *colophon*

यः श्रीशाहजहाँ[12] नृपालमुकुटालङ्कारचूडामणि-
स्तस्याज्ञामवलम्ब्य दुस्तरममुं सिद्धान्तसिन्धुं
तरन् ॥ नित्यानन्द इति द्विजोत्तमकृपः[13]
श्रीदेवदत्तात्मजस्त्रिप्रश्नप्रचुरोक्तियुक्तिसहितं काण्डं
द्वितीयं ह्यगात् ॥ (f. 28v: 15–18 Kh)

Nityānanda, who crosses over this unconquerable 'Ocean of the Siddhāntas [sc. composes the *Siddhāntasindhu*] [by] holding onto the command of Śri Shāh Jahān who is the crest jewel of the ornamental crown of kings, [the man who is worthy of] the mercy of the best Brāhmaṇas, the son of Śri Devadatta, has just finished the second part accompanied by many statements and rationales on the *tripraśna*.[14]

12 श्रीशाहजहाँ] श्रीशाहहाँ Kh. I suspect the scribe unwittingly left out the letter ज while copying; most other occurrences of Shāh Jahān's name in the text read श्रीशाहजहाँ (sometimes without the terminal nasal diacritic *candrabindu*), e.g., folia 3v: 1, 5r: 15, or 6v: 22 of Kh. Also, this verse is in the nineteen-syllabled *śārdūlavikrīḍita* meter which would require a five-syllabled word like श्रीशाहजहाँ० for metrical completion (*pada-pūrti*).

13 The appositive nominal compound द्विजोत्तमकृपः is grammatically irregular. The terminal word कृपः NOM-SING is attested as the sage Kṛpācārya (from the *Mahābhārata*) in Sanskrit lexicons. In this case, however, I suspect द्विजोत्तमकृपः is a metrical contraction (*pada-anatireka-karaṇa*) that can be parsed as द्विजोत्तमाणां कृपापात्रः '[the one] worthy of the mercy (*kṛpā*) of the best Brāhmaṇas'. In the colophon of Nityānanda's *Sarvasiddhāntarāja* (1639), we find a related phrase द्विजानामाज्ञाकारी 'one who executes the commands of the Brāhmaṇas' (i.e., obedient of the authority of Brāhmaṇas) as an epithet of Nityānanda (see Peterson 1892: 228; Dvivedi 1933: 102).

14 See § 2.2, remark 4 on page 56.

5 *ZĪJ-I SHĀH JAHĀNĪ* DISCOURSE II.6: TEXT AND TRANSLATION

f. 21b:20 Sj_A ⌈
f. 16a: 25 Sj_B

⌈باب ششم
در معرفت بعد کواکب از معدّل النهار.

[1] عرض کوکب و میل ثاني درجه او، اگر هر دو در یک جهت باشند جمع کنیم والا تفاضل بگیریم و آن را حصّه بعد خوانیم و جهت حصّه بعد جهت مجموع یا جهت فضل باشد.

[2] پس جیب حصّه بعد را در جیب تمام میل منکوس درجه کوکب منحطّ ضرب کنیم حاصل جیب ⌈بعد بود. f. 22a: 1 Sj_A⌉

[3] بوجهی[i] دیگر جیب حصّه بعد را در جیب تمام میل کلّی ضرب کنیم و حاصل را بر جیب تمام میل[ii] ثاني درجه آن کوکب قسمت کنیم خارج ⌈قسمت جیب بعد باشد و f. 16b: 1 Sj_B⌉ جهت آن جهت حصّه بعد باشد.

[4] و چون جیب حصّه بعد را در جدول جیب تمام میل کلّی درآرند و حاصل را بر جیب تمام میل ثاني درجه آن کوکب قسمت کنند خارج قسمت جیب بعد باشد.

[5] و اگر کوکب را عرض نباشد، میل درجه او بعد باشد.

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[i] بوجهی ⌋ بوقف‾‾‾‾‾جهی Sj_A. The overline 'وقف‾‾‾‾' over the word بوجهی is used to indicate a notable pause in the reading. As Gacek (2009: 173) explains, it is most likely a logograph (word-symbol) of the Arabic word قف (*qīf*) 'stop' to indicate a pause in reading; or alternatively, the abbreviation فت– (*fata–*) of the phrase فتأملها (*fataʾmmalhā*) 'reflect on it'.

[ii] میل ⌋ کلّی میل Sj_A, cancellation *intra lineam*.

Sixth chapter
On the knowledge (*maʿrifat*) of the distance of celestial objects from the celestial equator (*buʿd-i kawākib az muʿaddil al-nahār*).

[1] [Given] the latitude of a celestial object (*ʿarḍ-i kawkab*) and the second declination of its degree (*mayl-i thānī-yi daraji-yi u*), if both should be in one direction (*yik jahat*), we sum (**jamʿ kardan*) [them]; otherwise, we should take the difference (*tafāḍul*). And we call that [result] the share of the distance (*ḥiṣṣi-yi buʿd*). And the direction of the share of the distance (*jahat-i ḥiṣṣi-yi buʿd*) should be the direction of the sum (*jahat-i majmūʿ*) or the direction of the residue (*jahat-i faḍla*).

[2] Then, we low-multiply (**munḥaṭṭ-i ḍarb kardan*) the Sine of the share of the distance (*jayb-i ḥiṣṣi-yi buʿd*) in the Cosine of the inverse declination of the degree of a celestial object (*jayb-i tamām-i mayl-i mankūs-i daraji-yi kawkab*). The result (*ḥāṣil*) is the Sine of the distance (*jayb-i buʿd*).

[3] In another way, we multiply (**ḍarb kardan*) the Sine of the share of the distance (*jayb-i ḥiṣṣi-yi buʿd*) in the Cosine of the greatest declination (*jayb-i tamām-i mayl-i kullī*) [i.e., in the Cosine of the ecliptic obliquity] and we divide (**qismat kardan*) the result (*ḥāṣil*) over the Cosine of the second declination of the degree (*jayb-i tamām-i mayl-i thānī-yi daraji*) of that celestial object (*kawkab*). The quotient of the division (*khārij-i qismat*) should be the Sine of the distance (*jayb-i buʿd*), and its direction (*jahat*) should be the direction of the share of the distance (*jahat-i ḥiṣṣi-yi buʿd*).

[4] And since they extract (**dar ārdan*) [the product of the multiplication with] the Sine of the share of the distance (*jayb-i ḥiṣṣi-yi buʿd*) from the table of the Cosine of the greatest declination (*jadval-i jayb-i tamām-i mayl-i kullī*) [i.e., in the table of the Cosine of the ecliptic obliquity] and they divide (**qismat kardan*) the result (*ḥāṣil*) over the Cosine of the second declination of the degree (*jayb-i tamām-i mayl-i thānī-yi daraji*) of that celestial object (*kawkab*), the quotient of the division (*khārij-i qismat*) should be the Sine of the distance (*jayb-i buʿd*).

[5] And if a celestial object (*kawkab*) should have no latitude (*ʿarḍ*), the declination of its degree (*mayl-i daraji-yi u*) should be the distance (*buʿd*).

[6] و اگر عرض باشد اما درجه او را میل نباشد، جیب عرض او را در جیب تمام میل کلّی منحطّ ضرب کنیم یا در [iii] جدول سابق درآریم حاصل جیب بعد باشد و جهت او جهت عرض باشد.

[7] و اگر میل درجه او میل کلّی باشد، حصّة البعد بعینه بعد باشد.

[8] و بوجهی [iv] دیگر جیب بعد درجه کوکب از انقلاب اقرب در جیب تمام عرض کوکب منحطّ ضرب کنیم حاصل جیب بعد کوکب از دایرهٔ ماره باقطاب اربعه [v]–باشد.

[9] پس جیب عرض کوکب را بر جیب تمام بعد از دایرهٔ ماره باقطاب اربعه–[v] منحطّ قسمت کنیم [vi]–و به خارج قسمت–[vi] از جدول جیب قوس بگیریم و آن را قوس اوّل خوانیم و جهت آن جهت عرض کوکب بود.

[iii] یاد در ⟧ یا در Sj_B, dittography of the first د.

[iv] وبوجهی ⟧ و بوجهی Sj_A, with emphasis. See footnote [i].

[v]—[v] باشد. پس ... باقطاب اربعه ⟧

a. ط باشد پس ... باقطاب اربعه Sj_A, inserted in the exterior margin by the same hand. The penultimate word of passage [8] on f. 22a: 6 has an insertion mark '∧' (*signe-de-renvoi*) placed above it, sc. ... اربعه منحطّ ... باقطاب. The first word of the marginal text also bears the same mark, *supra verbum*, sc. ... پس باشد. The marginal text ends with 'ط': this could be a calligraphic variant of the abbreviation هی (*hāᶜ*) of the Arabic word إنتهی (*ʾintihā*) meaning 'it is finished', see Gacek (2009: 117);

b. باشد. پس ... باقطاب اربعه *omitted* Sj_B, per homeoteleuton. The penultimate word اربعه of passage [8], before the missing text, is identical to the last word of the missing text ... اربعه منحطّ in passage [9].

Remark: MS Or. 566 of the *Zīj-i Ulugh Beg* from University Library (Cambridge) is also missing the same amount of text. The missing words باشد ... اربعه span the length of a line between the end of line 18 (at اربعه) and the beginning of line 19 (at منحطّ) on folio 16r of this manuscript.

[vi]—[vi] و به خارج ⟧ و به خارج قسمت قسمت کنیم و به خارج قسمت Sj_B, dittography of the second و به خارج قسمت. I suspect a parableptic error as the word قسمت appears twice on the line in close proximity: ... قسمت ... از قسمت کنیم ... .

[6] And if the latitude (*ʿarḍ*) [of a celestial object] should exist but its degree (*daraji-yi u*) should have no declination (*mayl*), we low-multiply (**munḥaṭṭ-i ḍarb kardan*) the Sine of its latitude (*jayb-i ʿarḍ-i u*) in the Cosine of the greatest declination (*jayb-i tamām-i mayl-i kullī*) [i.e., in the Cosine of the ecliptic obliquity], or we extract (**dar ārdan*) [the product of this multiplication] from the preceding table (*jadval*) [i.e., in the table of the Cosine of the greatest declination]. The result (*ḥāṣil*) should be the Sine of the distance (*jayb-i buʿd*), and its direction (*jahat*) should be the direction of the latitude (*jahat-i ʿarḍ*).

[7] And if the declination of its degree (*mayl-i daraji-yi u*) should be the total declination (*mayl-i kullī*) [i.e., the obliquity of the ecliptic], the share of the distance (*ḥiṣṣat al-buʿd*) itself should be the distance (*buʿd*).

[8] And in another way, we low-multiply (**munḥaṭṭ-i ḍarb kardan*) the Sine of the distance of the degree of a celestial object from the nearest solstice (*jayb-i buʿd-i daraji-yi kawkab az inqilāb-i aqrab*) in the Cosine of the latitude of the celestial object (*jayb-i tamām-i ʿarḍ-i kawkab*). The result (*ḥāṣil*) should be the Sine of the distance of the celestial object from the 'circle passing through the four poles' [i.e., from the 'solstitial colure'] (*jayb-i buʿd-i kawkab az «dāyiri-yi mārri bi aqṭāb-i arbaʿi»*).

[9] Then, we low-divide (**munḥaṭṭ-i qismat kardan*) the Sine of the latitude of a celestial object (*jayb-i ʿarḍ-i kawkab*) over the Cosine of the distance [of the celestial object] from the 'circle passing through the four poles' (*jayb-i tamām-i buʿd*[*-i kawkab*] *az «dāyiri-yi mārri bi aqṭāb-i arbaʿi»*). And for the quotient of the division (*khārij-i qismat*), we should take the arc (*qaws*) from the table of Sine (*jadval-i jayb*). And we call it the first arc (*qaws-i avval*) and its direction (*jahat*) is the direction of the latitude of a celestial object (*jahat-i ʿarḍ-i kawkab*).

[10] پس اگر عرض و میل درجه کوکب هر دو در یک جهت باشند، قوس اوّل و میل کلّی را جمع کنیم. و اگر از ربع [vii] دور زیاده شود، تمام مجموع تا نصف دور بگیریم. و اگر در جهت مختلف باشند، تفاضل میان هر دو بگیریم حاصل قوس دوم باشد و جهتش جهت مجموع یا جهت فضل باشد.

[11] پس جیب قوس دوم را در جیب تمام بعد از دایرهٔ ماره باقطاب اربعه منحطّ ضرب کنیم حاصل جیب بعد کوکب باشد و جهتش جهت قوس دوم باشد.

[vii] ربع]
a. رابع Sj_A, erasure *intra lineam*;
b. رابع Sj_B. The Arabic words ربع (*rub^c*) and رابع (*rābi^c*) are the fractional ('one-fourth') and ordinal ('fourth') forms of the number four أربعة (*arba^{c}i*) respectively. The mathematical context of the passage supports the fractional meaning 'one-fourth' or a 'quarter'. The reading in Sj_B could be a semantic mistake by the scribe in copying Arabic loanwords (*mu^{c}arrab*).

[10] Then, if the latitude (*ʿarḍ*) and the declination of the degree of a celestial object (*mayl-i daraji-yi kawkab*) both should be in one direction (*yik jahat*), we sum (**jamʿ kardan*) the first arc (*qaws-i avval*) and the total declination (*mayl-i kullī*) [i.e., the obliquity of the ecliptic]. And if [the sum] exceeds (**ziyādi shudan*) one-quarter (*rābiʿ*) [i.e., is greater than 90°], we should take the whole sum (*tamām-i majmūʿ*) up to one-half (*niṣf*) [i.e., up to 180°]. And if they should be in different directions (*jahat-i mukhtalif*), we should take the difference (*tafāḍul*) between the two; the result (*ḥāṣil*) [in both cases] should be [called] the second arc (*qaws-i duvum*) and its direction (*jahat*) should be the direction of the sum (*jahat-i majmūʿ*) or the direction of the residue (*jahat-i faḍla*).

[11] Then, we low-multiply (**munḥaṭṭ-i ḍarb kardan*) the Sine of the second arc (*jayb-i qaws-i duvum*) in the Cosine of the distance [of a celestial object] from the 'circle passing through the four poles' (*jayb-i tamām-i buʿd az «dāyiri-yi mārri bi aqṭāb-i arbaʿi»*). The result should be the Sine of the distance of the celestial object (*jayb-i buʿd-i kawkab*) and its direction (*jahat*) should be the direction of the second arc (*jahat-i qaws-i duvum*).

6 *SIDDHĀNTASINDHU* PART II.6: TEXT AND TRANSLATION

⌈॥ अथ षष्ठाध्यायस्पष्टक्रान्तिज्ञानम्[i] ॥ ⌈f. 20r: 16 Kh

[1] खगस्य बाणो ऽन्यतरापमः[ii] पुन-
र्यदा द्वयं वैकदिशि स्थितं भवेत् ॥
तदा तयोः संयुतिरन्यथान्तरं
स्फुटापमांशाख्य[iii] इहोच्यते स्वदिक् ॥ १ ॥ *vaṃśasthavila*

[2] स्फुटापमाङ्कसिञ्जिनी सभत्रयद्युजीवया ॥
निहन्यते ऽधरीकृता स्फुटापमज्यका भवेत् ॥ २ ॥ *pramāṇikā*

[3] परमक्रान्तिकोटिज्या स्फुटक्रान्त्यङ्कजीवया ॥
हतान्यक्रान्तिकोटिज्याप्ता स्यात्स्पष्टापमज्यका ॥ ३ ॥ *anuṣṭubh*

[4] किंवा परमक्रान्तिज्याकोष्ठिकेभ्यः[iv] स्फुटक्रान्त्यङ्कज्यया गुणितफलमुत्थाय
द्वितीयक्रान्तिकोटिज्यया भजेल्लब्धं स्पष्टक्रान्तिज्या स्यात् ॥

[5] अथ च यदि खगस्य बणो न स्यात्तदा तस्य क्रान्तिरेव स्पष्टक्रान्तिर्भवेत् ॥

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[i] Looking at the orthography of the other chapter-titles (in Part II of Kh, see § 4), षष्ठाध्ये स्पष्टक्रान्तिज्ञानम् would be more consistent than षष्ठाध्यायस्पष्टक्रान्तिज्ञानम्. Nevertheless, I maintain the reading attested in Kh in the absence of a second manuscript witness. Besides, the locative sense (*adhikaraṇa*) of the modifier षष्ठ-[ऽ]ध्याय in the *tatpuruṣa* compound षष्ठ-[ऽ]ध्याय-स्पष्ट-क्रान्ति-ज्ञानम्$_{\text{NOM-SING}}$ is identical to the use of the prepositional phrase षष्ठ-[ऽ]ध्याये$_{\text{LOC-SING}}$ in the sentence षष्ठ-[ऽ]ध्ये स्पष्ट-क्रान्ति-ज्ञानम्$_{\text{NOM-SING}}$.

[ii] बाणोऽन्यतरपमः ⌋बाणेन्यतरपमः Kh. The conjoined word बाणेन्यतरपमः in Kh can be meaninfully segemnted as बाणे$_{\text{LOC-SING}}$ + अन्यतर-अपमः$_{\text{NOM-SING}}$. However, this reading (the second noun *in* the first) is contextually and semantically incoherent. The syntactic structure of the Sanskrit text mimics the syntax of the Persian text in passage [1], see § 2.3.2, remark 1a on page 60. This suggests that the emendation बाणो$_{\text{NOM-SING}}$ is better suited than बाणे$_{\text{LOC-SING}}$ as it agrees with अपमः$_{\text{NOM-SING}}$ in the subject-fronted noun phrase खगस्य-बानः-ऽन्यतर-अपमः पुनः.

[iii] ०मांशाख्य ⌋ ०मांशाख्यख्य Kh, dittography of the second ख्य.

[iv] An apposite reading of the compound परम-क्रान्ति-ज्या-कोष्ठिकेभ्यः should be परम-क्रान्ति-<कोटि>ज्या-कोष्टकेभ्यः. This would agree with an identical construction in passage [6] construed in the same mathematical context. There is, however, no visible evidence (e.g., interlinear lacunae or scribal corrections) on f2or: 20 Kh to suggest an omission. Therefore, I leave the attested reading unaltered in Sanskrit but include an emendation in my English translation.

Now, the knowledge (*jñāna*) of the true declination (*spaṣṭa-krānti*) in the sixth chapter.

[1] [Given] the latitude of a celestial object (*khagasya bāṇa*), [and] again, the other declination (*anyatara-apama*) [i.e., the second declination]: if indeed both should be situated in one direction (*eka-diś*), then [we take] the sum (*saṃyuti*) of both of them; otherwise, [we take their] difference (*antara*). [The result] is known as the share of the true declination (*sphuṭa-apama-aṃśa*). Here, [it is] said to be [in] its own direction (*sva-diś*). 1

[2] The Sine of the curve of true declination (*sphuṭa-apama-aṅka-siñjinī*), having been lowered (*adharī-kṛtā*), is multiplied (*ni-hanyate*) by the day-Sine [of the longitude] increased by three zodiacal signs (*sa-bha-traya-dyujīvā*) [i.e., Cosine of the first declination of the longitude increased by 90°]. [The result] will be the Sine of the true declination (*sphuṭa-apama-jyakā*). 2

[3] The Cosine of the greatest declination (*parama-krānti-koṭijyā*) [i.e., Cosine of the ecliptic obliquity], having been multiplied (*hatā*) by the Sine of the curve of true declination (*sphuṭa-krānti-aṅka-jīvā*) [and] having been divided (*āptā*) by the Cosine of the other declination (*anya-krānti-koṭijyā*) [i.e., Cosine of the second declination], should be the Sine of the true declination (*spaṣṭa-apama-jyakā*). 3

[4] Or, having extracted (*utthāya*) the product of the multiplication (*guṇita-phala*) with the Sine of the curve of true declination (*sphuṭa-krānti-aṅka-jyā*) from the tables of the <Co>sine of the greatest declination (*parama-krānti-<koṭi>jyā-koṣṭhika*s) [i.e., from the tables of the Cosine of the ecliptic obliquity], [one] should divide (*bhajet*) [that product] by the Cosine of the second declination (*dvitīya-krānti-koṭijyā*). The [result] obtained (*labdha*) [i.e., the quotient of the division] should be the Sine of the true declination (*spaṣṭa-krānti-jyā*).

[5] And now, if the latitude of a celestial object (*khagasya bāṇa*) should not exist, then its [first] declination (*krānti*) alone should be the true declination (*spaṣṭa-krānti*).

[6] अथ क्रान्तिर्यदि न स्यात्पुनः शरो भवेत्तदा बाणज्या परमक्रान्तिकोटिज्यया संगुण्याधः कुर्यात् ॥ किंवा परमक्रान्तिकोटिज्याकोष्ठकेभ्यो बाणज्यया गुणितफलमुत्थापयेत्स्पष्टक्रान्तिज्या बाणदिग्भवेत् ॥

[7] यदि खगस्य क्रान्तिः परमक्रान्तितुल्या स्यात्तदा स्पष्टक्रान्त्यङ्क एव स्फुटक्रान्तिर्भवति ॥

॥ अथ प्रकारान्तरेण ॥

[α] कदम्बविषवध्रुवद्वयमुपैति[v],[vi] वृत्तं च यत्
तदायनमुदीरितं[vii] ध्रुवचतुष्कयातं तथा ॥
नभोगविषवद्वयोपरि[viii] पतत्सुवृत्तं[ix] च यद्
भचक्रसदृशाह्वयं तदिति कल्पयेद्गोलवित् ॥ १ ॥ *pṛthvī*

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[v] The word विषव (as a part of a compound) appears several times in Kh. I suspect this is an irregular (vernacular?) variant of the word विषुव/विषुवत् that denotes the 'equinox/equinoctial point' in Sanskrit astronomical literature. See T. T. Bhaṭṭācārya (1962: p. 4934a) for the etymology of the word विषुव (*upapada tatpuruṣa*) or विषुवत् (*matvarthīya taddhitavṛtti* or secondary nominal derivative from विषु$_{\text{INDECL}}$ 'in both directions'). In a lager *tatpuruṣa* compound, विषुव/विषुवत् refers to the equatorial reference frame, e.g., in the genitive-compounds विषुववृत्त 'circle of the equinox' (i.e., the celestial equator) and विषुवत्-ध्रुव 'pole of the equinox' (i.e., the celestial pole). The word विषव is not an attested form in any Sanskrit lexicon; however, it is consistently and frequently used throughout Kh. Therefore, I maintain विषव$_{\text{IRREG}}$ (as attested in Kh) in the Nāgarī text but transliterate it using विषुव$_{\text{REG}}$ in my English translations. Both विषुव and विषव have the same metrical signature (⏑ ⏑ ⏑). [vi] °द्वयमुपैति ⌋ °द्वयमुपेति Kh. In the (emended) conjoined word °द्वयम्-उपैति, the terminal verb उपैति$_{\text{PRES-IND-SING-3rd}}$ is derived from उपे$_{\text{COMP-VB}}$. A regular sandhi of the words उप$_{\text{PVERB}}$ (indeclinable *upasarga*) + एति$_{\text{PRES-IND-SING-3rd}}$ produces उपैति and not उपेति (Pāṇini's *Aṣṭādhyāyī*: 6.1.89). The conjugated form एति derives from either √इ$_{\text{CL}_2}$ or its intensified version √ए$_{\text{CL}_2}$ (आ$_{\text{PVERB}}$ + √इ$_{\text{CL}_2}$). Any interpretation of उपेति (in Kh), e.g., उपेति$_{\text{NOUN}}$, is morphosyntactically inadmissible here. The choice of using the *guṇa* vowel (*e*-diacritic in पे) instead of the *vṛddhi* vowel (*ai*-diacritic in पै) is either a grammatical error or a scribal mistake. [vii] °यनमुदीरितं ⌋ °यनमुदीरीतं Kh. In the (emended) conjoined word °[ऽऽ]यनम्-उदीरितम्, the terminal compound verb उद्-√ईर्$_{\text{CL}_2}$ takes the affix -इत to form °उदीरितं$_{\text{CAUS-PAST-PASS-PTCP}}$ (used as an adjective). The word उदीरीतम् (in Kh) is grammatically ill-formed; I suspect the *ī*-diacritic in री is a scribal hypercorrection. [viii] °विषव°$_{\text{IRREG}}$ is identical to °विषुव°$_{\text{REG}}$ or °विषुवत°$_{\text{REG}}$, see footnote [v]. [ix] पतत्सुवृत्तं ⌋ तत्सुवृत्तं Kh. The third quarter नभोग°...°च यद् of the verse in passage [α] is metrically short by one syllable (hypometric): the verse otherwise follows a regular *atyaṣṭi samavṛtta* metre called *pṛthvī* with seventeen-syllables per quarter. The context of the verse, and its repetition in Nityānanda's *Sarvasiddhāntarāja* (*spaṣṭakrāntyādhikāra*: verse 4, Misra (forthcoming)), suggest तत्सुवृत्तं should be पतत्सुवृत्तं.

[6] Now, if the [first] declination (*krānti*) should not exist but the latitude (*śara*) should, then the Sine of the latitude (*bāṇa-jyā*) that must be multiplied (*saṃguṇyā*) by the Cosine of the greatest declination (*parama-krānti-koṭijyā*) [i.e., by the Cosine of the ecliptic obliquity], should [be made] lower (*adhaḥ kuryāt*). Or, [one] may [again] extract (*utthāpayet*) the product of the multiplication (*guṇitaphala*) with the Sine of the latitude (*bāṇa-jyā*) from the tables of the Cosine of the greatest declination (*parama-krānti-koṭijyā-koṣṭhaka*s) [i.e., from the tables of Cosine of the ecliptic obliquity]. [The result] should be the Sine of the true declination (*spaṣṭa-krānti-jyā*) in the direction of the latitude (*bāṇa-diś*).

[7] If the declination of a celestial object (*khagasya krānti*) should be equal to the greatest declination (*parama-krānti*) [i.e., the obliquity of the ecliptic], then the very curve of true declination (*spaṣṭa-krānti-aṅka*) becomes the true declination (*sphuṭa-krānti*).

Now, in another way.

[α] And what circle (*vṛtta*) reaches both the pair of ecliptic pole (*kadamba*) and the celestial pole (*viṣuvat* $_{\text{REG}}$*-dhruva*), that has been stated to be the solstitial [colure] (*āyana*[*-vṛtta*]), and also, the [circle] passing through the four poles (*dhruva-catuṣka-yāta*[*-vṛtta*]). And passing over a celestial object (*nabhoga*) and the pair of equinoctial points (*visuvat* $_{\text{REG}}$*-dvaya*), what [circle] is well rounded (*su-vṛtta*), that the knower of spheres (*gola-vid*) should consider as the [circle] congruent to the ecliptic (*bhacakra-sadṛśa*[*-vṛtta*]) by name. 1

[β] विषववृत्तभवृत्तसदृशयोर्विवर⌈गं[x] धनुरायनवृत्तजम् ॥ ⌈ f. 20v: 1 Kh
भवति यत्कथितः स परस्फुटापम इति द्युचरस्य च सम्प्रति ॥ २ ॥ *drutavilambita*

[γ] भवनचक्रभचक्रसदृक्षयोर्विवरगं धनुरायनवृत्तजम् ॥
भवति यत्स परेषुरिहोदितो विषवपातयुगे[xi] सति कल्पिते ॥ ३ ॥ *drutavilambita*

[δ] विषवन्नभोगमध्ये[xii] यत्कोदण्डं भवृत्तसदृशस्य ॥
ज्ञेयः सदृग्भुजो ऽसौ भायनविवरे सदृक्कोटिः ॥ ४ ॥ *āryā*

[8] खगस्य कोटिसिञ्जिनी स्वबाणकोटिजीवया ॥
हता ऽधरीकृता[xiii] भवेत्सदृक्षकोटिसिञ्जिनी ॥ ५ ॥ *pramāṇikā*

[9] तद्धनुर्नवतितश्च्युतं यदा जायते सदृशबाहुसंज्ञकम् ॥
या नभोगविशिखस्य सिञ्जिनी भाजिता ऽधरसदृक्षदोर्ज्यया ॥ ६ ॥ *rathoddhatā*
तद्धनुः परशराह्वयो भवेद्वा—

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[x] विषववृत्त॰ IRREG is identical to विषुववृत्त॰ REG, see footnote [v].
[xi] विषव॰ IRREG is identical to विषुव॰ REG, see footnote [v].
[xii] The word विषवत् is an attested secondary nominal derivative (from विष NOUN 'poison') meaning 'poisonous'. However, in the *tatpuruṣa* compound विषवत्-नभोग-मध्ये, I believe विषवत॰ IRREG, like विषव IRREG, is identical to ० विषुवत॰ REG, see footnote [v].
[xiii] हता ऽधरीकृता ⌋ हताधरीन्वता Kh. The conjoined words हताधरीन्वता in Kh can be segmented as हता PAST-PASS-PTCP (from √हन CL$_2$) + ऽधरीन्वता; however, the compound ऽधरीन्वता is etymologically defective by the rules of Pāṇinian grammar. The adverbial *CvI*-suffixation to अधर NOUN-STEM (making it अधरी PVERB) can only occur with terminal verbs √कृ CL$_8$, √भू CL$_1$, and √अस CL$_2$ when forming factitive compound verbs like √अधरी-कृ (Pāṇini's *Aṣṭādhyāyī*: 5.4.50), see Whitney (1879: 1094, p. 357).

A regular sandhi of the words हता PAST-PASS-PTCP + ऽधरीकृता PAST-PASS-PTCP (from √अधरी-कृ CL$_8$) generates हताधरीकृता that is morphologically correct and contextually apposite. Also, ऽधरीकृ CL$_8$ is variously attested in this chapter, as well as in Nityānanda's *Sarvasiddhāntarāja* (Misra forthcoming), in the same mathematical context. See glossary entry: lowering.

[β] What arc (*dhanus*) produced on the solstitial colure (*āyana-vṛtta*) becomes situated in the difference (*vivara*) between the celestial equator (*viṣuva* $_{\text{REG}}$*-vṛtta*) and the [circle] congruent to the ecliptic (*bhavṛtta-sadṛśa*[*-vṛtta*]), that is the stated [arc of] maximum true declination (*para-sphuṭa-apama*) of the celestial object (*dyucara*) just at that present moment. 2

[γ] What arc (*dhanus*) produced on the solstitial colure (*āyana-vṛtta*) becomes situated in the difference (*vivara*) between the ecliptic (*bhavana-cakra*) and the [circle] congruent to the ecliptic (*bhacakra-sadṛkṣa*[*-vṛtta*]), in this case, that is the declared [arc of] maximum latitude (*para-iṣu*) when the conjunction of the equinoctial point and the node of the orbit [of the celestial object] (*viṣuva* $_{\text{REG}}$*-pāta-yuga*) has been supposed. 3

[δ] What arc (*kodaṇḍa*) of the [circle] congruent to the ecliptic (*bhavṛtta-sadṛśa*[*-vṛtta*]) is between the equinoctial point (*viṣuvat* $_{\text{REG}}$) and the celestial object (*nabhoga*), that [arc] should be known as the congruent arc (*sadṛś-bhuja*); [and what is] between the celestial object (*bha*) and the solstitial colure (*āyana*[*-vṛtta*]), [that should be known as] the congruent complementary arc (*sadṛś-koṭi*) [i.e., complement of *sadṛś-bhuja*]. 4

[8] The Sine of the complement of the arc of ecliptic longitude of a celestial object (*khagasya koṭi-siñjinī*), having been multiplied (*hatā*) by the Cosine of its latitude (*sva-bāṇa-koṭijīvā*) [and] having been lowered (*adharī-kṛtā*), should be the Sine of the congruent complementary arc (*sadrkṣa-koṭi-siñjinī*) [i.e., Sine of the complement of the *sadṛś-bhuja*]. 5

[9] When [the measure of] its arc (*dhanus*), having been reduced from ninety [degrees] (*navatitaś-cyuta*), is determined, [it] has the name congruent arc (*sadṛśa-bāhu*). Or, what is the Sine of the latitude of a celestial object (*nabhoga-viśikhasya siñjinī*), having been divided (*bhājitā*) by the lowered Sine of the congruent arc (*adhara-sadrkṣa-dor-jyā*), 6...
...its arc (*dhanus*) should be [called] the maximum latitude (*para-śara*) by name.—

[10] —परेषुपरमापमाख्ययोः ॥
संयुतिर्वियुतिरस्ति च क्रमाद्गोलबाणसमभिन्नदिक्तया ॥ ७ ॥ *rathoddhatā*
स ग्रहस्य परमस्फुटापमो जायते युतिवियोगदिक्स्थितः ॥
एवमभ्रनवतो ऽधिको यदा खाष्टभू १८० परिमितैर्विशोधितः ॥ ८ ॥ *rathoddhatā*

[11] परस्फुटक्रान्तिभवज्यका हता सदृक्षबाहुज्यकया ऽधरीकृता ॥
तदीयचापं भवति स्फुटापमो दिगस्य संयोगवियोगदिक्समा ॥ ९ ॥ *vaṃśasthavila*

[10] —There is the sum (*saṃyuti*) or the difference (*viyuti*) of the two [quantities] known as the maximum latitude (*para-iṣu*) and the greatest declination (*parama-apama*) [i.e., the obliquity of the ecliptic] with the latitude (*bāṇa*) and the celestial hemisphere (*gola*) [i.e., the declination of the celestial object] in the same or different directions (*sama-bhinna-diś*) respectively. 7
That [result], being situated in the direction of the conjunction or the disjunction (*yuti-viyoga-diś*), becomes the maximum true declination of a celestial object (*grahasya parama-sphuṭa-apama*). Thus, when [its measure is] greater (*adhika*) than ninety [degrees] (*abhra-nava*), [it is] made to be subtracted (*viśodhita*) from a measure of one hundred and eighty [degrees] (*kha-aṣṭa-bhū*). 8

[11] The Sine of the maximum true declination (*para-sphuṭa-krānti-bhava-jyakā*), having been multiplied (*hatā*) by the Sine of the congruent arc (*sadṛkṣa-bāhu-jyakā*) [and] having been lowered (*adharī-kṛtā*), its arc (*cāpa*) becomes the true declination (*sphuṭa-apama*). Its direction (*diś*) is the same (*sama*) as the direction of the conjunction or the disjunction (*saṃyoga-viyoga-diś*). 9

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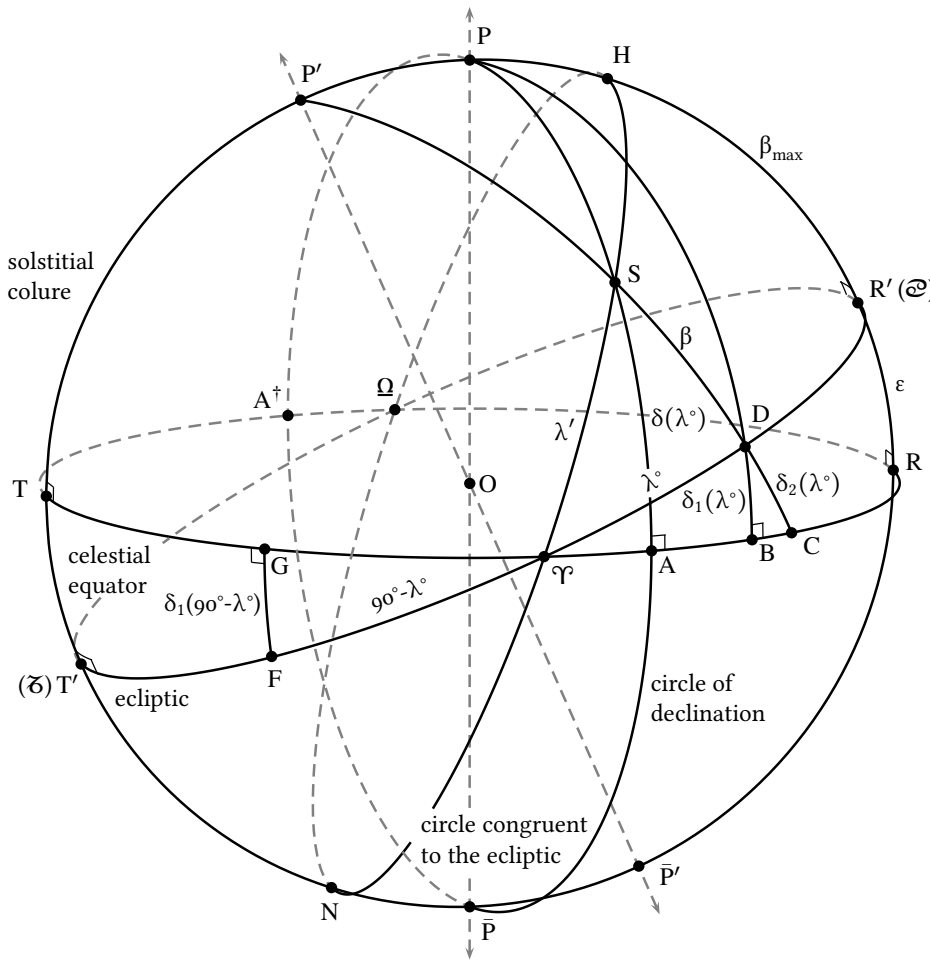
APPENDICES

A GEOMETRY ON THE CELESTIAL SPHERE



The celestial sphere with the various spherical triangles inscribed by the celestial equator, the ecliptic, a great circle congruent to the ecliptic and passing through the celestial object, and their different secondary circles.

Object	*Description*
O	centre of the celestial sphere
S	celestial object
P & $\bar{\text{P}}$	celestial poles
P′ & $\bar{\text{P}}'$	ecliptic poles
♈ & ♎	equinoctial points
R′ (♋) & T′ (♑)	solstitial points
⊙ ♈R ♎T	celestial equator
⊙ ♈R′ ♎T′	ecliptic
⊙ ♈SH ♎N	circle congruent to the ecliptic
⊙ P$\bar{\text{P}}'\bar{\text{P}}$P′	solstitial colure
⊙ PSA$\bar{\text{P}}$A†	circle of declination
◠ PR♈T♎	north celestial hemisphere
◡ $\bar{\text{P}}$T♎R♈	south celestial hemisphere
$\widehat{\text{DS}}$	latitude of a celestial object
$\widehat{\text{BD}}$	first declination of the ecliptic degree of a celestial object
$\widehat{\text{RR}'}$	obliquity of the ecliptic
$\widehat{\text{CD}}$	second declination of the ecliptic degree of a celestial object
$\widehat{\text{AS}}$	true declination of a celestial object
$\widehat{\text{CS}}$	curve of true declination of a celestial object
$\widehat{\text{♈D}}$	ecliptic longitude of a celestial object
$\widehat{\text{DR}'}$	complement of the ecliptic longitude of a celestial object
$\widehat{\text{♈S}}$	distance of a celestial object from the equinox
$\widehat{\text{SH}}$	distance of a celestial object from the solstice
$\widehat{\text{R}'\text{H}}$	maximum latitude of a celestial object
$\widehat{\text{RH}}$	maximum true declination of a celestial object
$\widehat{\text{GF}}$	inverse declination of the ecliptic degree of a celestial object

The three methods to compute the true declination of a celestial object, described in Mullā Farīd's *Zīj-i Shāh Jahānī* (*ZSJ*) Discourse II.6 and Nityānanda's *Siddhāntasindhu* (*SS*) Part II.6 (see Table 5), can be mathematically expressed as follows:[1]

First method, described in *ZSJ*:[2] prose and *SS*:[2] verse

$$\text{Sin}\,\widehat{\text{AS}} = \frac{\text{Sin}\,\widehat{\text{CS}} \times \text{Cos}\,\widehat{\text{GF}}}{\text{Sin}\,90^\circ} \qquad \text{or} \qquad \text{Sin}\,\delta = \frac{\text{Sin}\left[\delta_2(\lambda) + \beta\right] \times \text{Cos}\,\delta_1(90^\circ + \lambda)}{\mathcal{R}}$$

$$\text{where } \widehat{\text{CS}} = \widehat{\text{CD}} + \widehat{\text{DS}} = \delta_2(\lambda) + \beta \text{ and } \widehat{\text{GF}} = \delta_1(90^\circ - \lambda) = \delta_1(90^\circ + \lambda).$$

Second Method, described in *ZSJ*:[3] prose and *SS*:[3] verse

$$\text{Sin}\,\widehat{\text{AS}} = \frac{\text{Cos}\,\widehat{\text{RR}'} \times \text{Sin}\,\widehat{\text{CS}}}{\text{Cos}\,\widehat{\text{CD}}} \qquad \text{or} \qquad \text{Sin}\,\delta = \frac{\text{Cos}\,\varepsilon \times \text{Sin}\left[\delta_2(\lambda) + \beta\right]}{\text{Cos}\,\delta_2(\lambda)}$$

Third Method, described in *ZSJ*:[11] prose and *SS*:[11] verse

$$\text{Sin}\,\widehat{\text{AS}} = \frac{\text{Sin}\,\widehat{\text{RH}} \times \text{Sin}\,\widehat{\Upsilon\text{S}}}{\text{Sin}\,90^\circ} \qquad \text{or} \qquad \text{Sin}\,\delta = \frac{\text{Sin}\,(\varepsilon + \beta_{\text{max}}) \times \text{Sin}\,\lambda'}{\mathcal{R}}$$

$$\text{where } \widehat{\text{RH}} = \widehat{\text{RR}'} + \widehat{\text{R}'\text{H}} = \varepsilon + \beta_{\text{max}}.$$

1 I capitalise trigonometric functions to indicate a non-unitary radius, i.e., Sin = $\mathcal{R}$ sin and Cos = $\mathcal{R}$ cos where the radius $\mathcal{R}$ is the *sinus totus* or sine of 90°, taken as 60 in Mullā Farīd's *Zīj-i Shāh Jahānī* and Nityānanda's *Siddhāntasindhu*.

B PERSIAN AND SANSKRIT VERBS

The attested forms of Persian verbs from the *Zīj-i Shāh Jahānī* Discourse II.6 (§ 5) and of Sanskrit verbs from the *Siddhāntasindhu* Part II.6 (§ 6) are listed below separately. At the end of each entry, *passage-markers* in square brackets point to its location in § 5 or § 6 accordingly.

B.1 PERSIAN VERBS IN THE *ZĪJ-I SHĀH JAHĀNĪ* DISCOURSE II.6

1. بودن (*budan*) 'to be' باش (*bāsh*); بود [PRES-STEM] (*buvad*)[2]
   - باشند (*bāshand*) PRES- SBJV-PL·3rd '[they] should be' [1, 10]
   - باشد (*bāshad*) PRES- SBJV-SING·3rd '[he/she/it] should be' [1, 3–8, 10, 11]
   - نباشد (*nabāshad*) PRES- SBJV-SING·3rd (NEG) '[he/she/it] should not be' [5, 6]
   - بود (*buvad*) PRES-IND- SING·3rd '[he/she/it] is' [2, 9]
2. خواندن (*khāndan*) 'to recite' خوان (*khān*) [PRES-STEM]
   - خوانیم (*khānīm*) PRES- IND-PL·1st '[we] call' [1, 9]
3. درآوردن (*dar āvardan*) 'to remove/produce/ extract
   در آور (*dar āvar*) [VARIANT: در آر (*dar ār*)] [PRES-STEM]
   - درآورند (*dar āvarand*) [VARIANT: درآرند (*dar ārand*)] PRES-IND-PL ·3rd '[they] remove/produce/extract' [4]
   - درآوریم (*dar avarīm*) [VARIANT: درآریم (*dar ārim*)] PRES-IND-PL·1st '[we] remove/produce/extract' [6]
4. کردن (*kardan*) 'to do/make'[3] کن (*kun*) [PRES-STEM]
   - کنیم (*kunīm*) PRES-IND- PL·1st '[we] do/make' [1– 3, 6, 8–11]
   - کنند (*kunand*) PRES-IND- PL·3rd '[they] do/make' [4]
5. گرفتن (*giriftan*) 'to take/grab' گیر (*gīr*)[PRES-STEM]
   - بگیریم (*bigīrīm*) PRES- SBJV-PL·1st '[we] should take' [1, 9, 10]

2 See Chapter XI in Lenepveu-Hotz (2012: 251–268) for a diachronic study of the third singular present form of the verb 'to be' from the indicative بود (*buvad*) to the subjunctive باشد (*bāshad*) in the Persian verbal system (10th–16th CE).

3 The action verb کردن (*kardan*) is often used to construct compound verbs, e.g., جمع کردن (*jamaᶜ kardan*) 'to sum/add' or ضرب کنیم (*ḍarb kardan*) 'to multiply'.

B.2 SANSKRIT VERBAL FORMS IN THE *SIDDHĀNTASINDHU* PART II.6

1. (a) √अस् (√*as*) CL_2 'to be/exist'
   - अस्ति (*asti*) PRES-IND-ACT-SING·3rd '[he/she/it] is' [10]
   - सत् (*sat*) PRES-ACT-PTCP 'being' [γ]
   - स्यात् (*syāt*) OPT-ACT-SING·3rd '[he/she/it] should be/exist' [3–7]
     - न स्यात् (*na syāt*) OPT-ACT-SING·3rd (NEG) '[he/she/it] should not be/exist' [5, 6]

   (b) √जन् (√*jan*) CL_4 'to be born/determined'
   - जायते (*jāyate*) PRES-IND-MID-SING·3rd '[he/she/it] comes to be'/'[he/she/it] is determined' [9, 10]

   (c) √भू (√*bhū*) CL_1 'to be/become'
   - भवेत् (*bhavet*) OPT-ACT-SING·3rd '[he/she/it] should/will be' [1, 2, 5, 6, 8, 9]
   - भवति (*bhavati*) PRES-IND-ACT-SING·3rd '[he/she/it] becomes' [7, β, γ, 11]

   (d) √स्था (√*sthā*) CL_1 'to stand/situate'
   - स्थित (*sthita*) PAST-PASS-PTCP 'being stationed/situated'(ACT-sense) [1, 10]

2. (a) √उदीर् (√*udīr*) CL_2 'to state/utter'
   - उदीरित (*udīrita*) CAUS-PAST-PASS-PTCP 'has been stated to be' [α]

   (b) √कथ् (√*kath*) CL_{10} 'to declare/tell'
   - कथित (*kathita*) PAST-PASS-PTCP 'declared/told' (ADJ-use) [β]

   (c) √वच् (√*vac*) CL_2 'to say'
   - उच्यते (*ucyate*) PRES-PASS-SING·3rd '[he/she/it] is said [to be]' [1]

   (d) √वद् (√*vad*) CL_1 'to declare/state'
   - उदित (*udita*) PAST-PASS-PTCP 'declared/stated' (ADJ-use) [γ]

3. (a) √आप् (√*āp*) CL_5 'to reach' (in arithmetic, 'to divide')
   - आप्त (*āpta*) PAST-PASS-PTCP 'having been reached/divided' [3]

   (b) √भज् (√*bhaj*) CL_1 'to divide'
   - भजेत् (*bhajet*) OPT-ACT-SING·3rd '[he/she/it] should divide' [4]
   - भाजित (*bhājita*) CAUS-PAST-PASS-PTCP 'having been divided' (in a causal sense) [9]

4. (a) √नि-हन् (√*ni-han*) CL_2 'to strike in' (in arithmetic, 'to multiply')

- **नि-हन्यते** (*ni-hanyate*) PRES-PASS-SING·3rd '[he/she/it] is struck/multiplied' [2]
- **हत** (*hata*) PAST-PASS-PTCP 'having been struck/multiplied' [3, 8, 11]

(b) √**सं-गुण्** (√*saṃ-guṇ*) CL_{10} 'to multiply'

- **सं-गुण्य** (*saṃ-guṇya*) GDV 'to/must be multiplied' [6]

5. (a) √**च्यु** (√*cyu*) CL_1 'to deviate'/'be deprived of' (with ABL-use)
   - **च्युत** (*cyuta*) PAST-PASS-PTCP 'having deviated from'/'having been deprived of' [9]

   (b) √**वि-शुध्** (√*vi-śudh*) CL_1 'to purify/subtract'
   - **वि-शोधित** (*vi-śodhita*) CAUS-PAST-PASS-PTCP 'made to be purified/subtracted' [10]
6. √**उपे** (√*upe*) CL_2 'to reach'
   - **उपैति** (*upaiti*) PRES-IND-SING·3rd '[he/she/it] reaches' [α]
7. √**उत्था** (√*utthā*) CL_1 'to rise/extract'
   - **उत्थापयेत्** (*uthayet*) CAUS-OPT-ACT-SING·3rd '[he/she/it] may raise/extract' [6]
   - **उत्थाय** (*utthāya*) GER 'having risen/extracted' [4]
8. √**कृ** (√*kṛ*) CL_8 'to do/make'[4]
   - **कुर्यात्** (*kuryāt*) OPT-ACT-SING·3rd '[he/she/it] should do/make' [6]
   - **कृत** (*kṛta*) PAST-PASS-PTCP 'having been done/made' [2, 8, 11]
9. √**क्लृप्** (√*klp*) CL_1 'to consider/suppose'
   - **कल्पयेत्** (*kalpayet*) CAUS-OPT-ACT-SING·3rd '[he/she/it]' should consider/suppose' [α]
   - **कल्पित** (*kalpita*) CAUS-PAST-PASS-PTCP 'has been considered/supposed' [γ]
10. √**पत्** (√*pat*) CL_1 'to fall/pass'
    - **पतत्** (*patat*) PRES- ACT-PTCP 'falling/passing' [α]
11. √**ज्ञा** (√*jñā*) CL_9 'to know/understand'
    - **ज्ञेय** (*jñeya*) GDV 'to be known'/'to be understood' [δ]

4 The action verb √**कृ** (√*kr*) is often compounded with an inflected nominal word to form a denominative verb (CAUS, *nāmadhātu*), e.g., √**अधरी-कृ** (√*adharī-kṛ*) 'to make [something] low', i.e., 'to lower'.

LIST OF GRAMMATICAL ABBREVIATIONS

1st first person
3rd third person

ABL ablative case
ACT active voice
ADJ adjective

CAUS causative verb
CL class
COMP compound

DAT dative case

GDV gerundive
GER gerund

IND indicative mood
INDECL indeclinable
IRREG irregular form

LOC locative case

MID middle voice

MOD modifier

NEG negative form (negation)
NOM nominative case
NOUN noun

OPT optative mood

PASS passive voice
PAST past tense
PL plural
PRES present tense
PTCP participle
PVERB preverb

REG regular form

SBJV subjunctive mood
SING singular
STEM stem

VB verb

GLOSSARY

This glossary lists Persian and Sanskrit technical expressions from (i) the chapter-titles of *Zīj-i Shāh Jahānī* Discourse II and *Siddhāntasindhu* Part II in § 4, (ii) the Persian text of *Zīj-i Shāh Jahānī* Discourse II.6 in § 5, and (iii) the Sanskrit text of *Siddhāntasindhu* Part II.6 in § 6. Individual entries are grouped together under their common English translation. At the end of each entry, appropriate *chapter-numbers* and/or *passage-markers* in square brackets indicate its location in §§ 4, 5, or 6. See § 3.5 for a more detailed description of the format of the glossary.

altitude of the ecliptic pole or nonagesimal point—

↪ latitude of the visible climate عرض اقليم رؤيت (*ʿarḍ-i iqlīm-i ruʾyat*) II.18

↪ zenith distance of the ecliptic pole **दृग्गति** (*dṛggati*) II.18

↪ zenith distance of the nonagesimal point **दृक्क्षेप** (*dṛkkṣepa*) II.18

arc قوس (*qaws*) [9]; **धनुस्** (*dhanus*) [β, γ, 9], **कोदण्ड** (*kodaṇḍa*) [δ], **चाप** (*cāpa*) [11]

arc of daylight قوس النهار (*qaws al-nahār*) II.9

arc of maximum argument of the distance—

↪ maximum true declination **पर-स्फुट-अपम** (*para-sphuṭa-apama*) [β]

↪ maximum true declination of a celestial object **ग्रहस्य पर-स्फुट-अपम** (*grahasya para-sphuṭa-apama*) [10]

↪ second arc قوس دوم (*qaws-i duvum*) [10]

arc of maximum latitude—

↪ first arc قوس اوّل (*qaws-i avval*) [9, 10]

↪ maximum latitude **पर-इषु** (*para-iṣu*) [γ, 10], **पर-शर** (*para-śara*) [9]

arc of night قوس الليل (*qaws al-layl*) II.9

argument of the distance—

↪ curve of true declination **स्पष्ट-क्रान्ति-अङ्क** (*spaṣṭa-krānti-aṅka*) [7]

↪ share of the distance حصّهٔ بعد (*ḥiṣṣi-yi buʿd*) [1], حصّة البعد (*ḥiṣṣat al-buʿd*) [7]

↪ share of the true declination **स्फुट-अपम-अंश** (*sphuṭa-apama-aṃśa*) [1]

ascendant or rising zodiacal sign—

↪ ascendant طالع (*ṭāliʿ*), pl. طوالع (*ṭawaliʿ*) II.11, 21, 22; **लग्न** (*lagna*) II.21

↪ ascendant at each time طالع هر وقت (*ṭāliᶜ har vaqt*) II *incipit*

↪ ascendant at that time **तात्कालिक-लग्न** (*tātkālika-lagna*) II *incipit*

↪ ecliptic degrees of the ascendants **विलग्न-अंशक** (*vilagna-aṃśaka*) II.11

ascension or rising —

↪ [measure of] ascension مطلع (*maṭlaᶜ*), pl. مطالع (*maṭāliᶜ*) II.11, 13

↪ rising طالع (*ṭāliᶜ*), pl. طوالع (*ṭawaliᶜ*) II.13; **उदय** (*udaya*) II.12

↪ time of rising **उदय-समय** (*udaya-samaya*) II.13

azimuth—

↪ azimuth سمت (*samt*) II.14, 15

↪ degree of azimuth **दिश्-अंश** (*diś-aṃśa*) II.20

↪ degrees of azimuth in one's own location **स्व-दिश्-अंश** (*sva-diś-aṃśa*) II.14, 15

azimuth of *qibla* سمت قبله (*samt-i qibla*) II.20

celestial equator معدّل النهار (*muᶜaddil al-nahār*) II.5; **विषुव-वृत्त** (*viṣuva-vṛtta*)[5] [β]

celestial hemisphere **गोल** (*gola*) [10]

celestial object كوكب (*kawkab*), pl. كواكب (*kawākib*) II.13, 22, [3, 4, 5]; **ग्रह** (*graha*) II.7, **नक्षत्र** (*nakṣatra*) II.12, 13, **खग** (*khaga*) II.22, [1, 5, 7, 8] **नभोग** (*nabhoga*) [α, δ, 9], **द्युचर** (*dyucara*) [β], **भ** (*bha*) [δ]

celestial pole **विषुवत्-ध्रुव** (*viṣuvat-dhruva*)[6] [α]

circle **वृत्त** (*vṛtta*) [α]

circle of declination **क्रान्ति-सूत्र** (*krānti-sūtra*) II.5

circle passing through the equinoctial points and the celestial object—

↪ circle congruent to the ecliptic **भचक्र-सदृश-वृत्त** (*bhacakra-sadṛśa-vṛtta*) [α, δ], **भवृत्त-सदृश-वृत्त** (*bhavṛtta-sadṛśa-vṛtta*) [β], **भचक्र-सदृक्ष-वृत्त** (*bhacakra-sadṛkṣa-vṛtta*) [γ]

conjunction of the equinoctial point and the node of the orbit of a celestial object **विषुव-पात-युग** (*viṣuva-pāta-yuga*)[7] [γ]

5 Kh attests **विष̲व-वृत्त** (*viṣ̲ava-vṛtta*), an irregular form of **विषुव-वृत्त** (*viṣuva-vṛtta*), see § 6: footnote [x].

6 Kh attests **विष̲व-ध्रुव** (*viṣ̲ava-dhruva*), an irregular form of **विषुवत्-ध्रुव** (*viṣuvat-dhruva*), see § 6: footnote [v]. Another REG-form is **विषुव-ध्रुव** (*viṣuva-dhruva*).

7 Kh attests **विष̲व-पात-युग** (*viṣ̲ava-pāta-yuga*), an irregular of **विषुव-पात-युग** (*viṣuva-pāta-yuga*), see § 6: footnote [xi].

correlated numbers **परस्पर-सम्बन्धि-राशि** (*paraspara-sambandhi-rāśi*) II.2

Cosine of the distance of a celestial object from the 'circle passing through the four poles' **دایرۂ مارہ باقطاب اربعہ** جیب تمام بعد از (*jayb-i tamām-i buʿd az «dāyiri-yi mārri bi aqṭāb-i arbaʿi»*) [9, 11]

Cosine of the first declination of the longitude increased by ninety degrees—

↪ Cosine of the inverse declination of the degree of a celestial object جیب تمام میل منکوس درجہ کوکب (*jayb-i tamām-i mayl-i mankūs-i daraji-yi kawkab*) [2]

↪ day-Sine [of the longitude] increased by three zodiacal signs **स-भ-त्रय-द्युजीवा** (*sa-bha-traya-dyujīvā*) [2]

Cosine of the greatest declination جیب تمام میل کلّی (*jayb-i tamām-i mayl-i kullī*) [3, 6], **परम-क्रान्ति-कोटिज्या** (*parama-krānti-koṭijyā*) [3, 6]

Cosine of the latitude—

↪ Cosine of its latitude **स्व-बाण-कोटिजीवा** (*sva-bāṇa-koṭijīvā*) [8]

↪ Cosine of the latitude of a celestial object جیب تمام عرض کوکب (*jayb-i tamām-i ʿarḍ-i kawkab*) [8]

Cosine of the second declination—

↪ Cosine of the other declination **अन्य-क्रान्ति-कोटिज्या** (*anya-krānti-koṭijyā*) [3]

↪ Cosine of the second declination **द्वितीय-क्रान्ति-कोटिज्या** (*dvitīya-krānti-koṭijyā*) [4]

↪ Cosine of the second declination of the degree جیب تمام میل ثاني درجہ (*jayb-i tamām-i mayl-i thānī-yi daraji*) [3, 4]

declination—

↪ declination میل (*mayl*) [6]; **क्रान्ति** (*krānti*) II.5, [5, 6]

↪ declination of a celestial object **खगस्य क्रान्ति** (*khagasya krānti*) [7]

↪ declination of its degree میل درجہ او (*mayl-i daraji-yi u*) [5, 7]

↪ declination of the degree of a celestial object میل درجہ کوکب (*mayl-i daraji-yi kawkab*) [10]

declination of parts of the ecliptic میل اجزاء فلك البروج (*mayl-i ajzāʾ-i falak al-burūj*) II.5

definition **लक्षण** (*lakṣaṇa*) II.2, 8–13, 17–19, 22

having been divided आप्त (*āpta*) [3]
[one] should divide भजेत् (*bhajet*) [4]
having been divided भाजित (*bhājita*) [9]

ecliptic भवन-चक्र (*bhavana-cakra*) [γ]

ecliptic longitude—

↪ its degree درجه او (*daraji-yi u*) [6]
in other words, درجه کوکب (*daraji-yi kawkab*) 'degree of a celestial object'

ecliptic longitude of the meridian ecliptic point—

↪ degrees of the [meridian] ecliptic point at the [time of] rising of a celestial object भ-उदय-लग्न-अंश (*bha-udaya-lagna-aṃśa*) II.12

↪ [ecliptic] degree of the [meridian] transit [at the time of rising] of a celestial object درجهٔ ممرّ کوکب (*daraji-yi mamarr-i kawkab*) II.12

ecliptic pole कदम्ब (*kadamba*) [α]

elevation—

↪ desired degrees of elevation अभीप्सित-उन्नत-अंश (*abhīpsita-unnata-aṃśa*) II.14, अभीष्ट-उन्नत-अंश (*abhīṣṭa-unnata-aṃśa*) II.15, 21, 22

↪ elevation ارتفاع (*ʾirtifāʿ*) II.14, 15, 21, 22

equation of daylight—

↪ ascensional difference चर (*cara*) II.9

↪ equation of daylight تعديل النها (*taʿdīl al-nahār*) II.9

equinoctial point विषुवत् (*viṣuvat*)[8] [δ]

exceeds—

↪ exceeds to exceed زیادی شدن (*ziyādi shudan*) [10]

↪ greater अधिक (*adhika*) [10]

extract
to extract/bring out درآردن (*dar ārdan*) [4, 6]
having extracted उत्थाय (*utthāya*) [4]
may extract उत्थापयेत् (*utthāpayet*) [6]

having been reduced from ninety नवतितश्च्युत (*navatitaś-cyuta*) [9]

8 Kh attests विषवत् (*viṣavat*), an irregular form of विषुवत् (*viṣuvat*), see § 6: footnote [xii].

hours of day and night दिन-रात्रि-होरा (*dina-rātri-horā*) II.9

hours of daylight ساعات النهار (*sāᶜāt al-nahār*) II.9

hours of night ساعات الليل (*sāᶜāt al-layl*) II.9

inclination of the azimuth of *qibla* انحراف سمت قبله (*inḥirāf-i samt-i qibla*) II.20

integer-numbers of revolution—

↪ elevated [rank] مرفوع (*marfūᶜ*), pl. مرفوعات (*marfūᶜāt*), lit. raised up II.1

↪ revolution परिवर्त (*parivarta*) II.1

inverse method عمل عكس (*ᶜamal-i ᶜaks*) II.11

inverse procedure विलोम-क्रिया (*viloma-kriyā*) II.11

knower of spheres गोल-विद् (*gola-vid*) [α]

knowledge معرفت (*maᶜrifat*); ज्ञान (*jñāna*)
passim, seen in almost all chapter-titles of Discourse II and Part II

latitude—

↪ latitude عرض (*ᶜarḍ*) [5, 6, 10]; शर (*śara*) [6], बाण (*bāṇa*) [10]

↪ latitude of a celestial object عرض كوكب (*ᶜarḍ-i kawkab*) [1]; खगस्य बाण (*khagasya bāṇa*) [1, 5]

local meridian—

↪ line of midday خطّ نصف النهار (*khaṭṭ niṣf al-nahār*) II.16; मध्याह्न-रेखा (*madhyāhna-rekhā*) II.16

↪ line of the meridian याम्य-उत्तर-रेखा (*yāmya-uttara-rekhā*) II.16

local terrestrial coordinates—

↪ degrees of [terrestrial] longitude and latitude देशान्तर-अक्ष-अंश (*deśāntara-akṣa-aṃśa*) II.17

↪ longitude and latitude of a locality طول و عرض بلد (*ṭūl va ᶜarḍ-i balad*) II.17

low-division to low-divide منحطّ قسمت كردن (*munḥaṭṭ-i qismat kardan*) [9]

lowering—

↪ having been lowered अधरी-कृत (*adharī-kṛta*) [2, 8, 11]

↪ should [be made] lower अधः कुर्यात् (*adhaḥ kuryāt*) [6]

low-multiplication
to low-multiply منحطّ ضرب کردن (*munḥaṭṭ-i ḍarb kardan*) [2, 6, 8, 11]

maximum elevation and depression of a celestial object
غایت ارتفاع و انخفاض کوکب (*ghāyat-i ʾirtifāᶜ va inkhifāḍ-i kawkab*) II.7

method of identity **अनन्यत्व-प्रकार** (*ananyatva-prakāra*) II.15
tacitly, an argument following a method identical to one previously stated.

method of interpolation عمل تعدیل (*ᶜamal-i taᶜdīl*), lit. operation of adjustment II.2

minute دقیقه (*daqīqa*), pl. دقایق (*daqāʾiq*) II.1; **कला** (*kalā*) II.1

multiplication
to multiply ضرب کردن (*ḍarb kardan*) [3]
is multiplied **नि-हन्यते** (*ni-hanyate*) [2]
having been multiplied **हत** (*hata*) [3, 8, 11]
to/must be multiplied **संगुण्य** (*saṃguṇya*) [6]

ninety degrees—
↪ ninety **अभ्र-नव** (*abhra-nava*)[9] [10]
↪ one-quarter ربع (*rubᶜ*) [10]

north-south direction **सौम्य-याम्य-दिश्** (*saumya-yāmya-diś*) II.20

oblique ascension zodiacal signs in degrees—
↪ ascensions [of the ecliptic] of a locality مطالع بلد (*maṭāliᶜ-i balad*) II.10
↪ rising [of the zodiacal signs] in one's own location in degrees **निज-उदय-अंश** (*nija-udaya-aṃśa*) II.10, **स्व-उदय-अंश** (*sva-udaya-aṃśa*) II.11, 22, **निज-उदय-अंशक** (*nija-udaya-aṃśaka*) II.13

oblique diurnal circle **दिन-रात्रि-वाम-वृत्त** (*dina-rātri-vāma-vṛtta*) II.9

obliquity of the ecliptic—
↪ greatest declination **परम-क्रान्ति** (*parama-krānti*) [7], **परम-अपम** (*parama-apama*) [10]
↪ total declination میل کلّی (*mayl-i kullī*) [7, 10]

one hundred and eighty degrees—

9 *bhūtasaṃkhyā* word-numerals: *abhra* '0' and *nava* '9' forming '90'.

↪ one hundred and eighty **ख-अष्ट-भू** (*akha-aṣṭa-bhū*)[10] [10]

↪ one-half نصف (*niṣf*) [10]

pair of equinoctial points **विषुवत्-द्वय** (*viṣuvat-dvaya*)[11] [α]

place-value of sexagesimal digits—

↪ belong to a particular genus **जातीय** (*jātīya*) II.1

↪ genus جنس (*jins*) II.1

position مرتبه (*martaba*), pl. مراتب (*marātib*) II.1; **स्थान** (*sthāna*) II.1

quotient—

↪ obtained **लब्ध** (*labdha*) [4]

↪ quotient of division خارج قسمت (*khārij-i qismat*) II.1, [3, 4, 9]

result حاصل (*ḥāṣil*) [2–4, 6, 8, 10]; **फल** (*phala*) II.2

result of multiplication and division **गुणन-भजन-फल** (*guṇana-bhajana-phala*) II.1

result/product of multiplication—

↪ product of multiplication **गुणित-फल** (*guṇita-phala*) [4, 6]

↪ result of multiplication حاصل ضرب (*ḥāṣil-i ḍarb*) II.1

right ascension of the meridian ecliptic point—

↪ ascensions of [the degrees] of [meridian] transit مطالع ممرّ (*maṭāliᶜ-i mamarr*) II.12

↪ degrees of equatorial ascension of the [meridian] ecliptic point at the [time of] rising of a celestial object **भ-उदय-लग्न-व्यक्ष-उदय-अंश** (*bha-udaya-lagna-vyakṣa-udaya-aṃśa*) II.12

right ascension of zodiacal signs in degrees—

↪ ascensions [of the ecliptic] at the line of the terrestrial equator مطالع خطّ استوا (*maṭāliᶜ khaṭṭ-i istiva*) II.8

↪ ascensions [of the ecliptic] in the right sphere مطالع فلك مستقيم (*maṭāliᶜ falak-i mustaqīm*) II.8

10 *bhūtasaṃkhyā* word-numerals: *kha* ‘0’, *aṣṭa* ‘8’, and *bhū* ‘1’ forming ‘180’.

11 Kh attests **विषुव-द्वय** (*viṣava-dvaya*), an irregular form of **विषुवत्-द्वय** (*viṣuvat-dvaya*), see § 6: footnote [viii].

↪ rising [of the zodiacal signs] at Laṅkā in degrees **लङ्का-उदय-अंश** (*laṅkā-udaya-aṃśa*) II.8

↪ rising [of the zodiacal signs] at the terrestrial equator in degrees **व्यक्ष-उदय-अंश** (*vyakṣa-udaya-aṃśa*) II.8

rule of three **त्रै-राशिक** (*trai-rāśika*) II.2

same **सम** (*sama*) [11]

second ثانيه (*thāniya*), pl. ثواني (*thawānī*) II.1

second declination—

↪ other declination **अन्यतर-अपम** (*anyatara-apama*) [1]
synonymous with **अन्य-क्रान्ति** (*anya-krānti*) and identified with the **द्वितीय-क्रान्ति** (*dvitīya-krānti*) 'second declination'

↪ second declination of its degree میل ثاني درجه او (*mayl-i thānī-yi daraji-yi u*) [1]

shadow of a gnomon ظلّ (*ẓill*) II.4; **छाया** (*chāyā*) II.4

Sine جيب (*jayb*) II.3; **ज्या** (*jyā*) II.3

Sine of the argument of the distance—

↪ Sine of the curve of true declination **स्फुट-अपम-अङ्क-सिञ्जिनी** (*sphuṭa-apama-aṅka-siñjinī*) [2], **स्फुट-क्रान्ति-अङ्क-जिवा** (*sphuṭa-krānti-aṅka-jīvā*) [3], **स्फुट-क्रान्ति-अङ्क-ज्या** (*sphuṭa-krānti-aṅka-jyā*) [4]

↪ Sine of the share of the distance جيب حصّهٔ بعد (*jayb-i ḥiṣṣi-yi buʿd*) [2, 3, 4]

Sine of the complement of the ecliptic longitude—

↪ Sine of the complement of the arc of ecliptic longitude of a celestial object **खगस्य कोटि-सिञ्जिनी** (*khagasya koṭi-siñjini*) [8]

↪ Sine of the distance of the degree of a celestial object from the nearest solstice جيب بعد درجه كوكب از انقلاب اقرب (*jayb-i buʿd-i daraji-yi kawkab az inqilāb-i aqrab*) [8]

Sine of the distance along the 'circle congruent to the ecliptic' from the equinox—

↪ lowered Sine of the congruent arc **अधर-सदृक्ष-दोर्-ज्या** (*adhara-sadṛkṣa-dor-jyā*) [9]

↪ Sine of the congruent arc **सदृक्ष-बाहु-ज्यका** (*sadṛkṣa-bāhu-jyakā*) [11]

Sine of the distance along the 'circle congruent to the ecliptic' from the solstice—

↪ Sine of the congruent complementary arc **सदृक्ष-कोटि-सिञ्जिनी** (*sadṛkṣa-koti-siñjinī*) [8]

↪ Sine of the distance of a celestial object from the 'circle passing through the four poles' **دایرۂ مارہ باقطاب اربعہ** جیب بعد کوکب از (*jayb-i buᶜd-i kawkab az «dāyiri-yi mārri bi aqṭāb-i arbaᶜi»*) [8]

Sine of the latitude—

↪ Sine of its latitude جیب عرض او (*jayb-i ᶜarḍ-i u*) [6]

↪ Sine of the latitude **बाण-ज्या** (*bāṇa-jyā*) [6]

↪ Sine of the latitude of a celestial object جیب عرض کوکب (*jayb-i ᶜarḍ-i kawkab*) [9]; **नभोग-विशिखस्य सिञ्जिनी** (*nabhoga-viśikhasya siñjinii*) [9]

Sine of the maximum argument of the distance—

↪ Sine of the maximum true declination **पर-स्फुट-क्रान्ति-भव-ज्यका** (*para-sphuṭa-krānti-bhava-jyakā*) [11]

↪ Sine of the second arc جیب قوس دوم (*jayb-i qaws-i duvum*) [11]

Sine of the true declination—

↪ Sine of the distance جیب بعد (*jayb-i buᶜd*) [2, 3, 4, 6],

↪ Sine of the distance of the celestial object جیب بعد کوکب (*jayb-i buᶜd-i kawkab*) [11],

↪ Sine of the true declination **स्फुट-अपम-ज्यका** (*sphuṭa-apama-jyakā*) [2], **स्पष्ट-अपम-ज्यका** (*spaṣṭa-apama-jyakā*) [3], **स्पष्ट-क्रान्ति-ज्या** (*spaṣṭa-krānti-jyā*) [4, 6]

solstitial colure—

↪ circle passing through the four poles **ध्रुव-चतुष्क-यात-वृत्त** (*dhruva-catuṣka-yāta-vṛtta*) [α]
identified with the دایرۂ مارہ باقطاب اربعہ (*dāyiri-yi mārri bi aqṭāb-i arbaᶜi*) 'circle passing through the four poles'

↪ solstitial colure **आयन-वृत्त** (*āyana-vṛtta*) [α, β, γ, δ]

square root جذر (*jaḏr*) II.1; **मूल** (*mūla*) II.1

sum
to sum جمع کردن (*jamᶜ kardan*) [1, 10]
sum **संयुति** (*saṃyuti*) [1, 10]

table جدول (*jadval*) [6]; **कोष्ठक** (*koṣṭhaka*) [*varia lectio*: **कोष्ठिक** (*koṣṭhika*)] II.11

table of Sine جدول جیب (*jadval-i jayb*) [9]

table of the Cosine of the greatest declination جدول جیب تمام میل کلّی (*jadval-i jayb-i tamām-i mayl-i kullī*) [4]; **परम-क्रान्ति-कोटिज्या-कोष्ठिक** (*parama-krānti-koṭijyā-koṣṭhika*) [4], **परम-क्रान्ति-कोटिज्या-कोष्ठक** (*parama-krānti-koṭijyā-koṣṭhaka*) [6]

time—

↪ desired time **अभिमत-समय** (*abhimata-samaya*) II *incipit*

↪ time وقت (*vaqt*), pl. اوقات (*avqāt*) II *incipit*

Versed Sine—

↪ Sagitta سهم (*sahm*) II.3

↪ Versed Sine **शर** (*śara*) II.3

well rounded **सु-वृत्त** (*su-vṛtta*) [α]

whole sum تمام مجموع (*tamām-i majmūᶜ*) [10]

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Please write to ⟨wujastyk@ualberta.ca⟩ to file bugs/problem reports, feature requests and to get involved.
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