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A journal for the history of all forms of scientific thought and action, ancient and modern, in all regions of South Asia

Al-Bīrūnī's India, Chapter 14: an Account of Indian Astronomical, Mathematical and Other Literature

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INTRODUCTION

AL-BĪRŪNĪ'S KITĀB TAḤQĪQ MĀ LI-L-HIND (hereafter *Tahqīq*, ca. 1030 CE) is a mine of information for various aspects of Indian culture. Since al-Bīrūnī's main interest was in astronomy and astrology, it is natural that he devoted many pages of this book – in fact, half of it – to these two sciences. Much of its content that is related to these scientific fields is extremely precious to Indologists who study the history of science, because this testimony sheds light on Indian texts and authors who are otherwise not extant or unknown within Sanskrit literature. Today, our understanding of al-Bīrūnī's works, from the perspective of history of Indian astronomy and mathematics, mostly relies on studies done by Carl Edward Sachau, David Pingree, N. A. Baloch and E. S. Kennedy. There is, however, no monograph dedicated to this question, and information which can be drawn from these important studies is still fragmentary. In this article we would like to offer an English translation of Chapter 14, in which al-Bīrūnī gives very rich information on Indian astronomy and astrology.

Sachau published the Arabic edition of the *Tahqīq* in 1887, with a valuable introduction. Later, he translated the work into English (1888) with rich annotations.¹ Sachau laid the essential foundations for the study of al-Bīrūnī's book.

¹ We base our translation on the Hyderabad edition of the *Tahqīq*, referred to as *Tahqīq* (1958), and indicate when its reading di-

verges from that of Sachau's edition: *Tahqīq* (1887).



Even though he was not a Sanskritist, many of his identifications of Indian texts, authors and concepts remain valid today. A peculiarity of Sachau's translation, however, is that it is rather liberal, mostly when the Arabic original is obscure and intricate, and thus it can at times be misleading. Further, more than a century has passed since Sachau's publications. In the last hundred years, many works on Indian astronomy, astrology and mathematics have appeared. For instance, whereas Sachau knew about the existence of a manuscript of the *Brāhmasphuṭasiddhānta* (hereafter BSS), which he names *Brāhmasiddhānta*, probably following al-Bīrūnī's designation, he also writes that it had "not yet been completely edited or translated" at the time (Sachau 1888: II, 303). In 1973, N. A. Baloch edited and translated al-Bīrūnī's translation of the *Karaṇatilaka* (Baloch 1973). Baloch's introduction to the translations offered interesting insights into al-Bīrūnī's knowledge of Indian astronomy and the context in which he had prepared his translation. Baloch also discussed the transmission of Sanskrit astronomical works to the Abbasid caliphate in the middle of the eighth century CE. Lastly, especially important are David Pingree's works. His *Census of Exact Sciences in Sanskrit* (hereafter CESS) is one of the most significant contributions to Indology and history of science in the twentieth century.² Pingree's studies on the *Paulīśasiddhānta* and on the author Balabhadra have also been particularly helpful (Pingree 1969; 1983). With Pingree's works at hand we are in a position offer numerous additions and corrections to Sachau's translation. This paper offers some examples.

We begin by providing below an updated translation of Chapter 14 of the *Tahqīq* and – to the extent possible – we contextualize it in the footnotes. In this chapter, al-Bīrūnī gives the table of contents of the work which he calls *Brāhmasiddhānta*. In the appendix of the present article, we compare this list with the table of contents found in S. Dvivedin's edition of the *Brāhmasphuṭasiddhānta* (BSS).

² Since CESS is incomplete, we also referred

to his book *Jyotiḥśāstra* (Pingree 1981).

CHAPTER 14: ON THE RECORD OF THEIR BOOKS IN THE
OTHER SCIENCES³

Sciences are many, and by the periodic change of ideas about them, they increase when their time is favourable. The characteristic of such [time] is the desire and respect of people for [sciences] and its practitioners.

And those who are more entitled to this (i.e., the growth of science) are those who rule over the [people], because their (i.e., the rulers') work is to unload the hearts overwhelmed by worldly stress and to stimulate⁴ inclination to increase praise and favour, because hearts are disposed to the love of this and to the hate of its opposite.

Our time is not of this described characteristic. But on the contrary, if that is necessarily the case, when does a [new] science appear, or [when] does what has appeared progress?⁵

But what is found now is a residue and a remnant of the time which used to be of this characteristic. When something spreads all over the earth, all [groups of people] on [earth] receive their share. India is one of them. Their (i.e., Indians') belief in [cyclic] change of time agrees with visual observation.⁶

The science of stars is most famous among them, because the matters of religion are dependent on it. The title of astrologer and astronomer does not occur by mere computation to those who do not understand the judgements [of stars]. That which our authors know as "Sindhind" is [their] "Siddhānta" or "upright," not crooked and not changeable. This name refers to each science of

³ In the preceding two chapters of the *Tahqīq*, al-Bīrūnī discusses religious, grammatical and poetic literature. In chapter 14, he chiefly deals with astronomical, astrological and mathematical literature, while briefly mentioning the *Carakasaṃhitā* and the *Pañcatantra*. (On the *Carakasaṃhitā* in the *Tahqīq*, see also Sachau 1888:I, 162–3, 382–3.) In his translation of this title, Sachau adds elements absent in the Arabic original. His translation is as follows: "Hindu literature in the other sciences, astronomy, astrology, etc." (Sachau 1888:I, 152). In general, in the *Tahqīq* al-Bīrūnī very rarely uses a specific adjective referring to the Indians. When he does so, the Arabic term is either the collective noun *al-hind* (الهند), i.e., India or Indian, or a derived adjective *al-hindī* (الهندي), i.e., Indian. Sachau constantly translates these Arabic terms as "Hindu,"

and regularly adds the adjective, even when the term does not occur in the Arabic text.

⁴ *Tahqīq* (1887):73, line 4: *تَحْقِيقُ*, *Tahqīq* (1958):118, line 1: *تَحْقِيقُ*.

⁵ The Arabic passage is rather idiomatic. Sachau translates in the following way: "The present times, however, are not of this kind. They are the very opposite, and therefore it is quite impossible that a new science or any new kind of research should arise in our days" (Sachau 1888:I, 152).

⁶ This sentence appears a little out of context, but it simply serves as a transition sentence between the discussion on the developments of ideas and sciences and the actual topic considered hereafter in the chapter, science of stars. At any rate, al-Bīrūnī appears to consider (cyclic) change of time as true.

computation of stars that rises to the highest rank for them, even though for us they fall short of our Zīḡes, and they are five: (1) *Sūryasiddhānta* related to the sun, which Lāṭa composed. (2) *Vasiṣṭhasiddhānta* related to one of the stars of the Great Bear⁷ and which Viṣṇucandra composed.⁸ (3) *Pulisasiddhānta*, related to Paulisa,⁹ who was a Greek [man] from the city of Sayntara which I think is Alexandria¹⁰ and Pulisa composed [this text]. (4) *Romakasiddhānta*, related to Byzantium and which Aśrīkhīn composed.¹¹ (5) *Brāhmasiddhānta*¹² related to Brāhma and which Brahmagupta, the son of Jiṣṇu, composed in the city of Bhil-lamāla, which is between Multān and Anhilwāra,¹³ by [a distance of] 16 *yojanas*. All of them are based on the book of Paitāmaha which is related to the first father who is Brahmā.¹⁴

Varāhamihira composed a small-sized Zīḡ, which he calls *Pañcasiddhāntikā*. The title implies that it contains what are in the [afore-mentioned] five, but it is not [just] like that. And this [book] is not superior to them, so as to call it better than the five. But the name is established as five because of their number.¹⁵

Then, Brahmagupta says¹⁶ that the Siddhāntas are many. One of them is

7 Vasiṣṭha is ζ Ursae Majoris. Cf. *Bṛhat-saṃhitā* 13.5-6.

8 For Viṣṇucandra, see CESS: A5, 704. His name is found in BSS XI, 31, 50 and 55.

9 Pulisa/Paulisa is Pauliṣa in Varāhamihira's *Pañcasiddhāntikā* (PS). Pingree (1969) discusses the later Pulisa known to al-Bīrūnī.

10 The two Arabic editions read *sayntra* (سینتر). According to al-Bīrūnī, this corresponds to Alexandria. There are several cities known as Alexandria (Dey 1927: 4; Bhattacharyya 1991: 56-7).

11 Sachau identifies this name as Śrīsheṇa, i.e., Śrīṣeṇa, which is possible since the interchange of /ṣ/ and /kh/ is a common phenomena in north Indian writing systems. See below where *Ṣat-* of *Ṣatpañcaśika* is written *Khatt-*. Śrīṣeṇa is mentioned in BSS XI, 31, 46 and 55.

12 Actually, there exists a *Brahmasiddhānta* which is different from Brahmagupta's *Brāhmasphuṭasiddhānta*, edited by S. Dvivedin (Benares, 1901-1902, abbreviated BSS). The *Brahmasiddhānta* is included in the compendium *Jyotiṣasiddhāntasamgraha* edited by V. P. Dvivedin (Benares, 1912).

See the Appendix to this article (p.68 below) for a commented comparison of the division into chapters of the *Brahmasiddhānta* with that found in S. Dvivedin's edition of the *Brāhmasphuṭasiddhānta*.

13 Anhilwāra (انہلوآرہ), also known as Nahrwāra, corresponds to the Sanskrit toponym Anahilapurapattana and today's Pattan/Patan (23°52'N, 72°10'E) in Gujarat (Dey 1927: 6; Bhattacharyya 1991: 67, 227; Bosworth and Minorsky 1937: 88, 238, 245). Anhilwāra was ruled by a king known as Balla-ray (i.e., Vallabha-rāja of the Rāṣṭrakūṭa dynasty) in Arabic and Persian sources.

14 Pingree (1969: 177-9) discusses this passage.

15 This remark is not easy to understand. Al-Bīrūnī perhaps means that the title only refers to the number of the five well-known Siddhāntas, but that Varāhamihira's work differs from them in content. Anyway the *Pañcasiddhāntikā* al-Bīrūnī used might have been different from what we have today.

16 We cannot find the relevant passage of this statement. Therefore it is difficult to determine where exactly the quotation ends.

“Sūrya,” one of them is “Indu”,¹⁷ one of them is “Pulisa,” one of them is “Romaka,” one of them is “Vasiṣṭha,” and one of them is “Yavana”,¹⁸ namely Greek. In spite of their abundance, they don’t differ [from each other]; only the wording [differs], not the meaning. [A man] who looks at them with a right attention will find their [points of] agreement. By now I do not have any copy [of them], except the ones by Pulisa and by Brahmagupta. Its translation by me is still not complete, but I record the list of the chapters of the *Brāhmasiddhānta*, because this would be helpful for [its] understanding.¹⁹

1. On the conditions of the sphere and the shape of heaven and earth.²⁰
2. On the rotations of the planets and the study of time, the derivation of mean [longitude of] planets, and computation of the Sines (*ḡuyūb*) of arcs.
3. On the equation of planets.
4. On three questions which are the shadow [of gnomon], the time passed in the day, and the ascendant and derivation of one from the other.
5. On the appearance of the planets from the sun’s ray and their disappearance in it.
6. On the sight of the new moon (*hilāl*) and the condition of moon’s horns.
7. On the lunar eclipse.
8. On the solar eclipse.
9. On the shadow of the moon.
10. On the conjunction of the planets and their meeting.
11. On the latitudes of the [fixed] stars.
12. On the criticism of the books and the *Zīḡes* and on the distinction between the true and the false.
13. On mathematics and its study of plane geometry and others.
14. On the correction (*uttara*) of the mean planets.²¹
15. On the correction of the equation the planets.
16. On the correction of the three questions.

17 Since *indu* means the Moon, al-Bīrūnī might be referring to the *Somasiddhānta*, which is contained in the *Jyotiṣasiddhānta-saṃgraha* mentioned in footnote 12.

18 Yavana is mentioned again later as one of the books on astrology. We do not know any book on astronomy called Yavana.

19 See Appendix, p. 68 below.

20 In S. Dvivedin’s edition this is the 21st

chapter titled *Golādhyāya*. See Appendix. The text known to al-Bīrūnī is different from that of S. Dvivedin’s twentieth-century edition.

21 The word *uttara* has several meanings. Brahmagupta uses this word in the title of the second half of his *Khaṇḍakhādya* where he gives the “correction” of the first part.

17. On the deviation (deflection) of eclipses.
18. On the correction of the sight of the new moon (*hilāl*) and its horns.
19. On *kuṭṭaka*, which means "pounding," i.e. the endeavour to search for minute [things], from which oil is extracted. This is about *al-ḡabr wa-l-muqābala*,²² by putting together in search of other numbers.
20. On the matters of shadows.
21. On the computation of the metrics of poetry and its prosody.
22. On the rings and instruments.²³
23. On the time and four measures, namely solar, civil, lunar, and of the *nakṣatra*.
24. On the signs of the numbers and numerals in metrical treatises.²⁴

In this way are 24 chapters, as Brahmagupta said, while the 25th chapter is *Dhyānagrahādhyāya* in which emerges²⁵ the search for reflection (*fikra*)²⁶ without the study of mathematics.²⁷ I did not record it here (i.e., in the above enumeration of chapters), because I would depart from mathematics. I think that what he alluded to, with it, was the proofs of operations, otherwise how [can a man] draw something from this art [of astrology] without mathematics.²⁸ All [texts] which are below the rank of *siddhānta* are mostly called either *tantra* or *karaṇa*. As for *tantra*, its meaning is to act in the hand of a governor (i.e., to be subordinate or secondary). As for *karaṇa*, it means secondary, namely to *siddhānta*. In addition its experts are *ācāryas*, or learned ascetics who are followers of Brahmā.²⁹ Āryabhaṭa and Balabhadra³⁰ each has a famous *tantra*

22 The expression *al-ḡabr wa-l-muqābala* means "perfective addition and compensative subtraction" according to Lane's Lexicon (Lane 1863–93). The two words are technical terms of mathematical operation. The former is the origin of the modern term "algebra."

23 The word "ring" means armillary sphere.

24 This is al-Bīrūnī's misunderstanding. See Appendix.

25 The two editions read *الذي يخرج فيه* (*Tahqīq* (1887): 74, l. 13; *Tahqīq* (1958): 120, ll. 7–9). The MS reading is *الذي يخرج منه* according to Sachau's edition (*Tahqīq* (1887): 74, fn. 3).

26 This is al-Bīrūnī's understanding of *dhyāna*.

27 Actually *Dhyānagrahopadeśādhyāya* is full of highly mathematical computations. We think that this chapter could constitute a bridge between the Siddhānta of S. Dvivedin (BSS) and Karaṇa of the *Khaṇḍakhādya*. However, it seems that al-Bīrūnī did not understand this chapter.

28 Cf. The beginning of Wright 1934: 1.

29 The Arabic term *ʿāmilūna* (عاملون), translated here as "experts," literally means doers, workers, while also referring to the person in charge of an administrative office. Sachau for his part interprets the term as referring to the "governors," as follows: "Under governors they understand the Ācāryas, i.e., the sages, anchorites, the followers of Brahma." (Sachau 1888: v. 1, 155).

30 In the *Tahqīq*, al-Bīrūnī makes abund-

and Bhānurajas³¹ has a book *Rasāyana tantra* and *rasāyana* is explained in his book.³² As for the *karaṇa* related to its name (i.e., *rasāyana*?), it is Brahmagupta's *Khaṇḍakhādya*. This name refers to a sweet type [of food] among the [Indians]. I heard, concerning the reason of this [title], that Sugrīva, a Buddhist,³³ composed a Zīg called *Dadhisāgara*, namely the ocean of sour milk.³⁴ His disciple composed a Zīg called *Kūrababaya*,³⁵ namely “the mountain of rice.” Then Indu composed *Lavaṇamuṣṭi*, namely “a handful of salt.” And therefore, Brahmagupta called his book “candy” in order to make complete the meal and its ingredients. This [book] was based on the view of Āryabhaṭa and therefore he continued it with the book which he calls *Uttarakhaṇḍakhādya*, namely “its correction’.

Then, another book follows – I do not know whether it belongs to him (i.e., Brahmagupta) or to someone else – which is called *Khaṇḍakhādya*³⁶ in which the reasons of the numbers used in it (i.e., *Uttarakhaṇḍakhādya*) are given and which, as I think, belongs to Balabhadra. Vijayanandin,³⁷ the commentator from the city of Vārānasī, wrote a Zīg known by [the name] *Karaṇatilaka*, namely *Ġurra al-tawābi*^c.³⁸ Vaṭeśvara, the son of Mahadatta³⁹ from the city of Nāgpur

ant references to Balabhadra, chiefly when the discussion deals with astronomical and cosmological subjects. Sachau hypothesizes that Balabhadra could be the commentator of the *Kitāb Pātāṅgal* (Sachau 1888: v. 2, 264). This position is however not supported by evidence (Verdon 2020). On Balabhadra in al-Bīrūnī's work, see Pingree 1983.

31 CESS: A4, 294. Bhānurajas is entered as “the author of *Karaṇapratilaka*(?),” but no more information is given.

32 In the *Tahqīq*, al-Bīrūnī describes *rasāyana* ريسان as a fourth path leading to liberation, basing himself on the *Kitāb Pātāṅjal*. He further defines it as “procedures involving drugs resembling alchemy in the attainment of what is by nature impossible”

(هي تدابير بأدوية تحمري محمري الكيمياء في تحصيل الممتنعات بها)

Tahqīq (1958): 61 ll. 4–6; Sachau 1888: v. 1, 80. See also Sachau 1888: v. 1, 188–93.

33 Śamanā, Skt. *śramaṇa*.

34 A Persian word (الماس) is used here.

35 The Arabic transliteration *kūra-babaya* is most probably from the Sanskrit *kūraparvata* (*kūra*: boiled rice; *parvata*: mountain). The Sanskrit phonemes /p/ and /v/ in *parvata* were transliterated into Arabic by a

single sound /b/, in the same way as *vihāra* became *bihār* بهار in Arabic transliteration (*Tahqīq* (1958): 349, l. 9). Further, the original /r/ disappeared under a Prakrit influence. Lastly, as the Arabic letter /t/ (ت) and /y/ (ي) differ only by the diacritical signs it is possible that these were interchanged in the transliteration of the term.

36 Pingree 1983.

37 For Vijayanandin, see CESS: A5, 625. His name is referred to in S. Dvivedin (BSS) XI, 49 and 58.

38 Literally, the title *Ġurra al-tawābi*^c (غزة التوابع) means “ornament on the forehead of a dependency.” It seems to be a literal Arabic translation of the Sanskrit title *Karaṇatilaka*, the Arabic *tawābi*^c (plural of *tā'iba*) referring to something of minor importance and rendering the Sanskrit *karaṇa*, i.e., secondary. See also Baloch's translation of this title (Baloch 1973: 7). The Arabic translation of the *Karaṇatilaka* by al-Bīrūnī has been edited and translated into English by Baloch (1973). The title of the work in this edition is غزت الزيجات. See Baloch's translation of the two titles (Baloch 1973: 7).

39 Shukla 1985–6. See also CESS: A5, 555.

wrote a Zīg whose name is *Karaṇasāra*,⁴⁰ namely the extract from the secondary (i.e., *karaṇa*). Bhānurajas composed a book [entitled] *Karaṇapratilaka* as an extract from it.⁴¹ They assumed that the aspects of the planets are related to each other.⁴² Utpala, the Kaśmīrian, composed the *Rāhunnākaraṇa*,⁴³ namely “breaking of *tawābi*” and the *Karaṇapāta*,⁴⁴ namely “killing of *tawābi*”.⁴⁵

[Further, there is] the *Karaṇacūḍāmaṇi*. I do not know its author. Then, there are other books with other titles, such as the great *Mānasa*⁴⁶ from the work of Manu⁴⁷ and which Utpala commented on, and the small *Mānasa*,⁴⁸ which Mañjula⁴⁹ from the southern district composed. And the *Daśagītikā* of Āryabhaṭa and his *Āryāṣṭaśata*.⁵⁰ *Lokānanda*⁵¹ by the name of its author, and the book by Bhattila⁵² the Brahmin, [titled] by his name. You will hardly count [the books] of this genre.

As for their books on astrology (*aḥkām al-nuḡūm*), each of the following [authors] Māndavya (?),⁵³ Parāśara,⁵⁴ Garga,⁵⁵ Brāhma, Balabhadra,⁵⁶ Divyātātva⁵⁷ composed, and Varāhamihira composed a book [called] [*Bṛhat*] *Samhitā*, whose definition is: a collection which contains in abundance a little bit of everything, such as report on travelling⁵⁸ by the phenomena of the sky, matters

40 There is no entry for *Karaṇasāra* in CESS.

41 See footnote 31.

42 The meaning of this sentence is unclear. Sachau connects it to the previous sentence, as follows: “another one, by Bhāṇuyāśas (?), is called *Karaṇaparatilaka*, which shows, as I am told, how the corrected places of the stars are derived from one another” (Sachau 1888: I, 157). Sachau’s Bhāṇuyāśas should be Bānurajas.

43 CESS: A4, 283, *Rā.h.t(?) .ra karaṇa (Ārdharātrikakaraṇa?)*.

44 According to Pingree (CESS: A4, 283), *Karaṇaghāta*, or ‘Killing of *karaṇa*’ is Utpala’s work.

45 The meaning of “killing of *tawābi*” is not clear. A similar idea may be found in the example of Mādhava, a Sāṃkhya teacher, who was referred to as *sāṃkhyānāśaka*, i.e., destroyer of Sāṃkhya, “because he deviated from the Sāṃkhya position” (Larson and Bhattacharya 2008: 147).

46 This is *Bṛhanmānasa* of Muñjāla (or Mañjula). See CESS: A4, 435.

47 This should be Mañjula.

48 See Shukla 1990, especially page 4.

49 Arabic text is پنچل which Sachau reads “Puñcala.”

50 *Daśagītikā* is the first chapter of *Āryabhaṭīya*, but sometimes it is regarded as an independent work. The rest of the *Āryabhaṭīya*, consisting of 108 Āryā verses, is called *Āryāṣṭaśata* as a work on its own. Al-Bīrūnī reflects the tradition which regards the *Daśagītikā* and the *Āryāṣṭaśata* as two separate works.

51 No information about this book or author is available in CESS.

52 No information is available in CESS.

53 Arabic text reads *māndabba* مانتدب.

54 There are many Parāśaras. See CESS: A4, 194–202.

55 Garga is the author of the *Gārgyajyotiṣa* (CESS: A2, 116f). Bill Mak organized a working group on Garga tradition. The recent result is: Geslani et al. 2017.

56 For Balabhadra see CESS: A4, 233. See also Pingree 1983: 353–60.

57 Pingree only gives his name (CESS: A3, 112).

58 *yātrā* in Sanskrit. Especially military expeditions.

of dynasties⁵⁹ and interrogation,⁶⁰ then physiognomy,⁶¹ dreams,⁶² and *zağr*.⁶³ Their learned people believe in it and they follow the prescription of the astrologers which they interpret from the knowledge of phenomena of the sky and cosmos by the *Samhitā*. Each one of [the authors] Parāśara, Satya,⁶⁴ Mañittha,⁶⁵ Jīvaśarman,⁶⁶ Mau⁶⁷ the Greek, composed a book [known as] *Jātaka*, namely book on nativity. Varāhamihira composed two books on this [topic], small and large⁶⁸ and Balabhadra commented on it. I translated the smaller of the two into Arabic.⁶⁹

On the topic on nativity, they have a large book called *Sārāvalī*,⁷⁰ that is an anthology like the *Pazīdağ*⁷¹ which Kalyānavarman the king composed, and which reflects scientific excellence. A book, larger than this [one], which brings together all subjects related to astrology, is known as *Yavana*⁷², i.e., belonging to the Greeks. And Varāhamihira composed small books, among which [one is] *Ṣaṭpañcasikā*,⁷³ i.e., 56 subjects on interrogations, a book *Horāpañcahatarā* (?) also on this topic. Concerning journeys, [he has] books [entitled] *Yogayātrā* and the *Tikanikayātrā*,⁷⁴ concerning marriage and wedding, a book *Vivāhapaṭala*,⁷⁵ and concerning architecture ... (lacuna). Then on *zağr*,⁷⁶ omen and the like, there is

59 This refers to a kind of astrology which developed in Persia. The famous historian Ibn Khaldūn discusses this topic in his *Muqaddima*. It offers the interpretation of historical events, especially that of dynasties. This kind of astrology is absent in India, although a book of this kind is ascribed to “Kanaka al-Hindī.”

60 This genre is called *praśna* (lit. question) in Sanskrit. According to Pingree 1981: 101 ff it corresponds to the “catarchic astrology.”

61 For physiognomy (*puruṣalakṣaṇa*), see Zysk 2016.

62 On dream (*svapna*) Michio Yano has prepared an English translation, which has not been published yet, of the *svapna* chapter of the *Atharvavedapariśiṣṭa*.

63 This word corresponds to Sanskrit *śākuna* (literally omen), a prognostication by the behaviour of animals. According to Steingass (Arabic-English dictionary), the term *zağr* (جر) refers to an omen based on the flight of birds, from the verbal root, *zağara* meaning “to take omen from birds’ flight.”

64 Satya is frequently quoted in Utpala’s commentary on the *Bṛhajjātaka*. See Pingree 1981: 83–84.

65 CESS: A4, 343. Mañittha is a Greek.

66 Cf. CESS: A3, 70. Jīvaśarman is quoted by Varāhamihira in the *Bṛhajjātaka* 7.9 and 11.1.

67 Probably Maya who was regarded as the author of the *Sūryasiddhānta*.

68 *Laghujātaka* and *Bṛhajjātaka*, respectively.

69 In chapter 80 of the *Tahqīq*, al-Bīrūnī offers translations of passages drawn from the *Laghujātaka*. See Arabic text, *Tahqīq* (1958): 529–35 and *Tahqīq* (1887): vol. 2, 225–34.

70 For the *Sālāvalī* of Kalyānavarman, see CESS: A2, 26.

71 Persian word? البریدج

72 This is the *Yavanajātaka*, edited and translated by Pingree (1978).

73 Al-Bīrūnī is mistaken here. The author of *Ṣaṭpañcasikā* is Prthuyāśas, the son of Varāhamihira. See CESS: A4, 277 f; A5, 219 ff, and Pingree 1981: 110–11.

74 Both *Yogayātrā* and *Tikanikayātrā* are Varāhamihira’s works on expedition. It is surprising that al-Bīrūnī does not mention *Bṛhadyātrā*.

75 For Varāhamihira’s *Vivāhapaṭala*, see CESS: A5, 573. See also Sugita (2001).

76 See footnote 63.

a book [entitled] *Surūdava*⁷⁷ and it exists in three copies.⁷⁸ One of them is attributed to Mahādeva.⁷⁹ The author of the second [one] is Vimalabuddha,⁸⁰ while that of the third [copy] is Baṅgāla.⁸¹ There [exists] a book, *Cūdāmaṇi*,⁸² i.e., the science of the supernatural, composed by a Buddhist, an author who is a *śramaṇa* wearing a red garment, and a book, *Praśna Cūrāmaṇi*, i.e., questions on the science of the supernatural, which Utpala composed.⁸³ Among their savants whose names are not handed down with [their] books, are: Pradyumna,⁸⁴ Sangahil,⁸⁵ Divākara,⁸⁶ Pareśvara,⁸⁷ Sārasvata,⁸⁸ Pīruvāna,⁸⁹ Devakīrti,⁹⁰ and Pṛthūdakasvāmin.⁹¹

The science of medicine is like the science of stars except that it (i.e., astral science) is entangled with religion. And they have a book, known by [the name of] its author who is Caraka,⁹² and which they prefer among their books on medicine. [They] believe about him that he was a *ṛṣi* in the last Dvāpara [yuga] and that his name was Agniveśa. Later on, he was named Caraka, that is the intelligent [one], after he obtained medicine from the best children of Sūtra, who were *ṛṣis*. These [*ṛṣis*] received it from Indra and Indra received it from Aśvinī,⁹³ one of the two physician *devas*, who received it from Prajāpati, who is Brahman the first father.⁹⁴ This book was translated into Arabic for the Barmakids family.⁹⁵ They have variety of several other sciences. You [can] hardly count [their] books, but I could not comprehend them by [my] knowledge. I wish I could translate the book *Pañcatantra*, which is known among us as the book *Kalīla wa-Dimna*. It moved to and fro between Persian and Indian [languages] and later on Arabic. The Persian [version comes] from the mouth of people whose alternation is not faithful to it (i.e., original version?), such as ‘Abd al-lāh ibn al-Muqaffa’ by his addition of the chapter on “Barzūya” in [his version], aiming at awakening doubt

77 CESS: A4, 283, *S.rū.dh.w* (*Sūtradhāra*?).

78 *Tahqīq* (1887): 75, l. 19 ثلث; *Tahqīq* (1958): 122, l. 14 ثلاث.

79 It is difficult to identify this person.

80 There is no entry for this person in CESS.

81 Nothing is known about Baṅgāla.

82 See CESS: A3, 52; Pingree (1981: 88).

83 CESS: A4, 283, where *Praśnacūrāmaṇi* = *Āryasaptati* which is again = *Praśnajñāna* = *Bhuvanadīpikā* = *Jñānamālā* (CESS: A4, 282).

84 Pradyumna is attested in S. Dvivedin (BSS) XI, 46 and 58.

85 There is no entry for Sangahil in CESS.

86 Divākara before al-Bīrūnī is not known.

87 There is no entry for Pareśvara in CESS.

88 Nothing is known about Sārasvata.

89 There is no entry for Pīruvāna in CESS.

90 There is no entry for Devakīrti in CESS.

91 For Pṛthūdakasvāmin, see CESS: A4, 221. His full name is Caturveda Pṛthūdakasvāmin (fl. 864). His commentary on S. Dvivedin (BSS) Chapter 21 (Chapter 1 according to al-Bīrūnī) was studied by Ikeyama (2003). Pṛthūdakasvāmin’s commentary on the *Khaṇḍakhādyaka* is edited and translated by Sengupta (1934).

92 For Caraka in the Islamic world, see Meulenbeld (1999–2002: 1A, 116).

93 The Arabic text reads Aśvinī (أشوني). Aśvins are twins and regarded as the physicians of gods.

94 This episode is described in *Caraksasamhitā* 6.1.4.4.

95 On the Barmakids see van Bladel (2011). See also Sachau (1888: I, xxxi–xxxii; II, 313.).

of [people who are] weak in religious beliefs and at their breaking in order to call [them] up to the Manichean creed. If he is suspect regarding what he added, he is not free from the same regarding what he translated.⁹⁶

⁹⁶ The Sanskrit collection of fables, known as *Pañcatantra*, was translated into Pahlavi and Syriac in the mid-sixth century CE. It was transmitted into Arabic during the eighth century under the title *Kalīla wa-Dimna*, which reflects the Sanskrit names of two important protagonists of the original stories, i.e., Karāṭaka and Damaṅaka. As

al-Bīrūnī notices, the book *Kalīla wa-Dimna* was neither literal nor direct translation of the *Pañcatantra*. ‘Abd Allāh Ibn al-Muqaffaʿ (ca. 720–756), on the basis of the Pahlavi text, made some modifications in his Arabic translation of it (Brockelmann 2012; Gabrieli 2012).

APPENDIX: CONTENTS OF THE BRĀHMASPHUṬASIDDHĀNTA

Al-Bīrūnī's <i>Tahqīq</i>	Dvivedin's edition
(1) في أحوال الكرة وهيئة السماء والارض	(21) golādhyāya
(2) في أدوار الكواكب ومزاولة الازمنة اإستخراج	(1) madhyamādhikāra
أوسات الكواكب والحيوب القسى	(2) spaṣṭādhikāra
(3) في تقويم الكواكب	(2) spaṣṭādhikāra
(4) في الأسئلة الثلاث التي هي الظل والماضى	(3) tripraśnādhikāra
من النهار والطلع وإستخراج بعضها من بعض	(6) udayāstādhikāra
(5) في ظهور الكواكب من شعاع الشمس واختفائها به	(6) udayāstādhikāra
(6) في رؤية الهلال وحال قرنيه	(7) candraśṛṅgonatyādhikāra
(7) في كسوف القمر	(4) candragrahaṇādhikāra
(8) في كسوف الشمس	(5) sūryagrahaṇādhikāra
(9) في ظل القمر	(8) candracchāyādhikāra
(10) في اجتماع الكواكب واقتنائها	(9) grahayutyadhikāra
(11) في عروض الكواكب	(10) bhagrahayutyadhikāra
(12) في إنتقاد ما في الكتب والزيجات وتمييز الصحيح من السقيم	(11) tantraparīkṣādhyāya
(13) في الحساب ومزاولته في المساحات وغيرها	(12) gaṇitādhyāya
(14) في تحقيق أوساط الكواكب	(13) madhyagatyuttarādhyāya
(15) في تحقيق تقويم الكواكب	(14) sphuṭagatyuttarādhyāya
(16) في تحقيق الاسولة الثالثة	(15) tripraśnottarādhyāya
(17) في انحرافات الكسوف	(16) grahaṇottarādhyāya
(18) في تحقيق رؤية الهلال وقرنيه	(17) śṛṅgonatyuttarādhyāya
(19) في كتك وهو الدق على معنى تشبيه الاجتهاد في الطلب بدق	(18) kuṭṭakādhyāya
ما يستخرج منه الدهن وهو في الجبر والمقابلة بالمقرنات	
وفي مطالب أخر عددية	
(20) في امور الظل	(19) śaṅkucchāyādijñānādhyāya
(21) في حسابات أوزان الشعر وعروضه	(20) chandaścityuttarādhyāya
(22) في الدوائر الالات	(22) yantrādhyāya
(23) في الأزمان والمقادير الأربعة	(23) mānādhyāya
(24) في علامات الأعداد والأرقام في خلال المنظومات	(24) saṃjñādhyāya
(25) دهنگرهاڈها	(25) dhyānagrahopadeśādhyāya

GENERAL COMMENTS

The sequence of the chapters found in al-Bīrūnī's work differs from that of Dvivedin's edition. His chapter 1 corresponds to chapter 21 in Dvivedin. His chapters 2 to 4, correspond to chapters 1 to 3 of Dvivedin's. His chapters 5 and 6 correspond to chapters 6 and 7 in Dvivedin respectively, while his chapters 7 and 8 are Dvivedin's chapters 4 and 5. From al-Bīrūnī's chapters 9 to 21, the chapter numbers correspond to Dvivedin's 8 to 20. Chapters 22 to 25 in Arabic and Sanskrit exactly correspond.

In chapter 14 of the *Tahqīq*, al-Bīrūnī explains that he did "not have any copy [of them] (i.e., Siddhānta), except the ones by Pulisa and by Brahmagupta." The extent to which he could actually access Brahmagupta's work or parts of it is uncertain. Indeed, in the preceding chapter of the *Tahqīq*, dealing with grammar and metrical science, al-Bīrūnī states the following:⁹⁷

I have not studied a thing about them (i.e., books on metrical science), nor about most of the chapter in the *Brāhmasiddhānta* which deals with the calculation of [metrical science]

ولم أطلع على شيء منها ولا على كثير من المقالة التي في براهم سدهاند في حسابها

He also makes this striking comment:⁹⁸

I have only read one leaf of the afore-mentioned chapter (i.e., in the *Brāhmasiddhānta*) and this [chapter] most certainly contains precious things, as principles related to numbers

ولم أطلع من المقتلة المذكورة إلا ورقة واحدة وهي لا محالة مشتملة على نفائس من الاصول العددية

The discrepancy in the arrangement of chapters may be due to a difference of textual transmission, but if al-Bīrūnī did not read the whole manuscript, then the oral commentary by his Indian informants may also account for this difference. Whereas there is evidence that he frequently adapted his Sanskrit sources when rendering them into Arabic, in case of enumerations he adds explanations but does not generally change the sequence of listed items.⁹⁹

⁹⁷ *Tahqīq* (1958):106, ll. 14–15, Sachau 1888: I, 137–38.

⁹⁸ *Tahqīq* (1958):117, ll. 12–14, Sachau 1888: I, 150–51.

⁹⁹ See Maas and Verdon (2018: 315–28) on al-Bīrūnī's interpretative choices and Verdon (2020) on his way of dealing with lists.

Thus, there is little chance that this difference results from al-Bīrūnī's own reworking. Further, so far, only one manuscript and one edition of Sanskrit exist of the *Brāhmasphuṭasiddhānta*.¹⁰⁰ This difference, then, may imply that the text which he accessed was different in some respects from that which has been transmitted to us. In addition to this main discrepancy, al-Bīrūnī complemented some chapters' titles with explanations of their content. On the whole, however, his translation is rather true to the original subject matter. We provide below specific comments on al-Bīrūnī's wording, as compared to the Sanskrit list:

Taḥqīq 1: Al-Bīrūnī paraphrases the original title by explaining that sphere (Skt. *gola*; Ar. كرة) is both celestial and terrestrial.

Taḥqīq 2: Al-Bīrūnī provides more details about the content of the chapter.

Taḥqīq 3: Al-Bīrūnī does not give a literal translation but refers in his title to the mathematical operation through which the mean planet becomes its apparent position.

Taḥqīq 4 and 5: Al-Bīrūnī provides with a paraphrase.

Taḥqīq 11: Al-Bīrūnī uses the term latitude (عروض) in the title; which shows that he understood its content, because the conjunction of planet and *nakṣatra* implies this calculation. This title also indicates the two possible translations of the Arabic term *kawākib* (كواكب) as planets or stars.

Taḥqīq 12: Al-Bīrūnī paraphrases here the original Sanskrit title and differentiates between books (كتب) and astronomical tables, or *Ziḡes* (زيجات). The Sanskrit titles, from this chapter onward, contain the word *adhyāya* (chapter) instead of *adhikāra* (section). The reasons for this change are unclear.

Taḥqīq 13: Al-Bīrūnī refers to the Sanskrit *kṣetragaṇita* (lit. calculation of plane figures), by the term plane geometry (المساحات).

Taḥqīq 14: Al-Bīrūnī translates *uttara* by the Arabic تحقيق. The Sanskrit term signifies either "second part" or "correction" in different contexts. In the Sanskrit corresponding chapter (Dvivedin 13), Brahmagupta provides a correction of the computation of mean planets which was given in his chapter 1 (*Taḥqīq* 2; Dvivedin 1).

Taḥqīq 17: Al-Bīrūnī does not translate the term correction by تحقيق here, which raises the question of whether this difference in the titles reflects a difference in the chapter's content.

Taḥqīq 19: It is the only place in this list where al-Bīrūnī transliterates the Sanskrit term into Arabic. However, he could not provide an Arabic translation of this title, which refers to a specific algorithm developed by Indian mathematicians/astronomers. Instead, he explains it as meaning,

¹⁰⁰ There is a printed edition by Śarmā et al. (1966), but it is totally based on the edition

by S. Dvivedin (BSS).

pounding, i.e., the endeavour to search for the minute [things], from which oil is extracted. This is about algebra (الجبر والمقابلة), by “putting together in search of other numbers.”

Al-Bīrūnī appears to first provide his readers with an etymological explanation, and subsequently with a mathematical one.

Tahqīq 21: The content of this chapter in Sanskrit dealing with *chandas*, or metrical science, is very obscure and difficult to understand. Al-Bīrūnī deals with *chandas* in chapter 13 of the *Tahqīq*.¹⁰¹

Tahqīq 22: Rings (دوائر) or armillary spheres were used for demonstrations, while instruments (الات) for observations.

Tahqīq 23: Al-Bīrūnī lists the four measures of time as follows: solar, civil, lunar, and of the mansions (منازلي), i.e., of the *nakṣatras*. He knew well about them, as he discussed them separately in *Al-āṭār al-bāqīya*,¹⁰² the *Tafhīm*¹⁰³ and the *Tahqīq*.¹⁰⁴

Tahqīq 24: The title of this chapter in the edition of S. Dvivedin (BSS) is *Samjñā-dhyāya*, or “Chapter on the technical terms.” But in this chapter, consisting of only 13 verses, Brahmagupta gives a summary of the second part of the *Brāhmasphuṭasiddhānta* and therefore this chapter is a kind of colophon. Thus al-Bīrūnī’s title is misleading.

¹⁰¹ *Tahqīq* (1958): 105, l. 17–117 l. 18, Sachau 1888: I, 136–52.

¹⁰² Sachau 1878: 13, ll. 4–10; 1879: 15.

¹⁰³ Wright 1934: 169.

¹⁰⁴ *Tahqīq* (1958): 297, l. 9–299 l. 17, Sachau 1888: I, 353–56.

ABBREVIATIONS

- Brahmasiddhānta* Dvivedin, V. P. (1912) (ed.), *Brahmasiddhānta* in *Jyautiṣa-siddhāntasamgrahaḥ tatra Pitāmahasiddhāntaḥ, Vṛddhavasīṣṭha-siddhāntas ca* (Benares Sanskrit Series, 154; Benares: Braj Bhushan Das & Co.), 1–79, <http://n2t.net/ark:/13960/t6353t221>; the last work in the compendium.
- BSS Dvivedin, S. (1901–2) (ed.), *Brāhmasphuṭasiddhānto Dhyānagrahopadeśādhyāyās ca, GaṇakacakracūdāmaṇiSṛīBrahmagupta-viracitaḥ = Brāhmasphuṭasiddhānta and Dhyānagrahopadeśādhyāya by Brahmagupta* (The Pandit, New Series, 23 and 24; Benares: Medical Hall Press), <http://n2t.net/ark:/13960/t9f50913n>.
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