

Garga and Early Astral Science in India

Marko Geslani, Bill Mak, Michio Yano et Kenneth Zysk

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Résumé de l'article

This article forms a preliminary report on the work by an international group of scholars on Garga, an important early authority on astral science (jyotiṣa). Reviewing past research on the texts associated with this figure, we focus especially on the earliest text, the Gārgīyajyotiṣa (ca. first century CE?), a compendium of material on astral and terrestrial omens, ritual, horoscopy, and astronomy, that prefigures Varāhamihira's well-known *Bṛhatsaṃhitā*. The contributions include text-critical observations based on select chapters, remarks on astral omens and their relevance to the possible dating of the text, and a discussion of the text's potential for the study of Hindu ritual. The article also begins to disambiguate the broader Garga corpus by including a chapter summary of a somewhat later *Gargasamhitā*, containing mainly astronomical materials.

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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

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Emory University, Kyoto University, Kyoto Sangyo University and University of Copenhagen

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Garga and Early Astral Science in India

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Emory University, Kyoto University, Kyoto Sangyo University and University of Copenhagen

1. INTRODUCTION (MAK)

Within the *jyotiṣa* tradition of India, Garga has long been considered one of the most important authorities, if not the earliest, on a variety of subjects in the astral sciences. A number of scholars—from Weber and Kane to more recently Pingree and Mitchiner—have dated texts attributed to Garga to around the first century CE, with source materials of possibly much older origin.¹ In the commentaries of Bhaṭṭotpala on the *Brhatsaṃhitā* and the *Brhajjātaka*, the two authoritative works on natural astrology and horoscopy composed by the sixth-century polymath Varāhamihira, works attributed to Garga (or Vṛddhagarga) are among those most often cited.² References to Garga are found also in Mīnarāja's *Vṛddhavyavanajātaka* (fourth century CE?) and Varāhamihira's various works.³ However, none of the extant works attributed to Garga has yet been edited or published in its entirety. This situation prompted Pingree in 1987 to describe the *Gārgīyajyotiṣa*—one of the most comprehensive of Garga's texts—as an “immense and immensely important work,” and to opine that its editing was a task of utmost urgency.⁴

Here we begin a closer examination of this seminal authority by looking at the earliest surviving documents, i.e., the manuscripts.

¹ Weber 1852: 225; Kane 1949: 6–9; Pingree 1963: 232–33, Pingree 1981: 69–71 (first century BCE or CE), Pingree 1987a: 295 (first or possibly second CE); Mitchiner 2002: 81 f. See also Burgess 1858: 420; Kern 1865: 31, 40; Dīkṣita 1896: 405; Negelein 1928: 1–2.

² In the *Samhitāvivṛti*, commentary to the *Brhatsaṃhitā*, Garga was cited in 189 instances in 448 ślokas, surpassed only by Parāśara, 206 instances in 132 ślokas and 667 prose lines (Tripathi ed.). In the *Jagacandrikā*, commentary to the *Brhajjātaka*,

Garga was cited in 39 instances in 65.5 ślokas, following only the *Yavanajātaka*, which was quoted in 64 instances in 73.5 *upajāti*, verses. See Mitchiner 2002: 113–20, Sugita 1992: 14–16, Mak 2018. For discussion of the identities of Garga and Vṛddhagarga, see Kane 1949: 8, Mitchiner 2002: 11 f.

³ Pingree 1981: 71 f.

⁴ Pingree 1987a: 297. On the text-designation, *Gārgīyajyotiṣa*, see Mitchiner 1986: 4.

Version	Title and content
G1	<i>Gārgīyajyotiṣa</i> , a dialogue on astral and other omens between Krauṣṭuki (Rṣiputra) and Garga in 64 <i>aṅgas</i> . ⁵
G2	An astrological work that claims to be following the teaching of Garga. 37 <i>adhyāyas</i> .
G3	<i>Vṛddhagārgīsaṃhitā</i> , a dialogue on astrology between Nārada and Vṛddhagārgya- or -Vṛddhagārgi.
G4	<i>Gargasaṃhitā</i> , a dialogue on astronomy between Bhāradvāja and Garga. 20 <i>adhyāyas</i> .
G5	<i>Gārgyasaṃhitā</i> on history in at least 12 <i>adhyāyas</i> .
G6	<i>Uttaragārgyasaṃhitā</i> or <i>Nārāyaṇīya</i> in many <i>adhyāyas</i> of which only 30–51 are available.
G7	Unidentified <i>Gargasaṃhitā</i> .
G8	Short tracts that claim to be derived from a <i>Gargargasaṃhitā</i> : (a) <i>Arghakāṇḍa</i> ; (b) <i>Kākaruta</i> ; (c) <i>Kākavaikṛtyaśānti</i> ; (d) <i>Ketūdayaphala</i> ; (e) <i>Jvaraśānti</i> ; (f) <i>Dhvajādhyāya</i> ; (g) <i>Pallīsarata</i> ; (h) <i>Meghamālā</i> .

Table 1: Eight works attributed to an author Garga according to Pingree (CESS: A2).

SOURCES

According to Pingree's survey, there are no less than thirty-four distinct works of the *jyotiṣa*, genre bearing a title associated with Garga.⁶ The exact relations between these works, with topics ranging from planetary omens and bird divination to horoscopy and astronomy, await further investigation. What is certain is that the Garga referred to in these titles should not be considered a single author.⁷ This authorial complexity behind the name "Garga" is assumed throughout this study.

Among the most extensive works of Garga in terms of both scope and size is the *Gārgīyajyotiṣa*, which Pingree called the "first *Gargasaṃhitā* (G1)".⁸ To this

⁵ We follow here Mitchiner's designation of "*aṅga*" for the main divisions of the work as described in the content list given in the second of the two introductory chapters of the *Gārgīyajyotiṣa*, titled "Enumeration of the Divisions" or *Aṅgasamuddiśa* (Mitchiner 1986: 10, 102). See further discussion in § 3, p. 163, below.

⁶ CESS: A2, 115–26; A3, 29–30; A4, 78–80; A5, 78–84.

⁷ For example, Pingree identified another Garga (ca. tenth century) of Jaina affiliation, who authored the *Pāśakevalī* (CESS: A2, 122).

⁸ We follow here Mitchiner 1986: 101–12. Cf. Pingree 1987a: 293. Pingree also called

author, Pingree attributed a total of eight works as summarized in Table 1.⁹

Three of our contributors (Zysk, Mak, Geslani) focus on the *Gārgīyajyotiṣa* (G1), while the final contributor (Yano) discusses the “astronomical” *Gargasamhitā* (G4), which bears no direct relation to G1. In the process of disambiguating the corpus, one should bear in mind the fluidity of this tradition attributed to Garga.

By itself, the *Gārgīyajyotiṣa* (G1) is a large and somewhat fluid collection of individual chapters (see Appendix A). The main manuscripts of G1 we have consulted are the following:¹⁰

- A** Asiatic Society, Kolkata, 1D20. 160 ff. JH C-177 PMF 597.
- *B** Banaras (Sampūnānand) Sanskrit University, Varanasi. 36370. 137 ff. CESS: A2, 117.
- Bh** Bhandarkar Oriental Research Institute, Pune. 542 of 1895–1902, new no. 12 section. 193–4/226 ff. CESS: A2, 117. JH C-135 PMF 285.
- *C** Gangajala Vidyapeeth, Aliyavada, Gujarat. 127. 241 ff. CESS: A5, 78.
- *D** National Library, Kolkata. Th 319. 295 ff. CESS: A5, 78.
- E** Bhandarkar Oriental Research Institute, Pune. 345 of 1879–80. 232 ff. CESS: A2, 117.
- F** Bhandarkar Oriental Research Institute, Pune. 36 of 1874–75. 79 ff. CESS: A2, 117. JH C-177 PMF 572. JH C-154X. Pingree transcription “DEP notes *Gargasamhitā*, 2 of 2” (APS Box 14).
- G** Cambridge Trinity College, Cambridge. R.15.96. 109 ff. CESS: A2, 117. JH C-175 PMF 491. Pingree transcription “DEP notes *Gargasamhitā*, 1 of 2” (APS Box 14).
- *H** Banaras Hindu University, Varanasi. 2B/1288, Sanskrit Mahāvidyālaya no. 34. 227 ff. CESS: A5, 78.

this text “*Vṛddhagargasamhitā* or *Vṛddhagārgīyā*”—under type “1” of the *Gargasamhitā* (CESS: A2: 116–17)—but he generally referred the text as the first version of the *Gargasamhitā* (Pingree 1981: 69).

⁹ I have collated here the descriptions by Mitchiner (2002) and Pingree (CESS: A2: 116–20, 1981: 69–74).

¹⁰ This collection is an expansion of Zysk

2016: 2: 463–80, which was in turn based on Mitchiner 2002: 21–25. The sigla follow those of Mitchiner. * indicates manuscripts which are only partially available to us. APS = American Philosophical Society, Pingree archive; JH = John Hay Library Pingree Collection; PMF = John Hay Library microfilm number. We thank in particular Koji Kumagai for sharing his copies of the manuscripts.

- *L National Library, Kolkata. Th 171. 147 ff. **CESS**: A5, 78.
- M Bombay University, Mumbai. Itcchārām Sūryarām Desāi Collection 1433. 192/398 ff. **CESS**: A2, 117. JH C-173 PMF 408.
- *N National Library, Kolkata. Th 216. 228 ff. **CESS**: A5, 78.
- P Bibliothèque Nationale, Paris. 245. 208 ff. **CESS**: A2, 117; A3, 29.
- R Rajasthan Oriental Research Institute, Alwar. 2602. 245 ff. **CESS**: A5, 78.
- *S Banaras (Saṃpūṇānand) Sanskrit University, Varanasi. 35311. 201 ff. **CESS**: A2, 117.

“ASTRONOMICAL” GARGASAṂHITĀ (G4)

- I Vishveshvaranand Vedic Research Institute, Hoshiarpur. 2069. 201 ff. **CESS**: A2, 118. Pingree transcription “6” (JH C-103).

PAST RESEARCH

Although the *Gārgīyajyotiṣa* remains by and large in manuscript form, a number of chapters have been separately edited and translated. A few critical editions and studies of individual chapters include: the *Yugapurāṇa* (*aṅga* 41), edited and published together with an English translation and a historical analysis by Mitchiner (1986); the *Śukracāra* (*aṅga* 6), translated by Pingree (1987a) with a commentary largely comprised of comparisons between Sanskrit *jyotiṣa* texts and Babylonian materials from the *Enūma Anu Enil*;¹¹ a portion of the *Rāṣṭrot-pāṭalakṣaṇa* (*aṅga* 39), edited and translated into English and Japanese by Kumagai (2007, 2011, 2015); and finally the *Puruṣalakṣaṇa* / *Strīlakṣaṇa* (*aṅga* 48), edited with critical notes and published with English translation in a comprehensive study of Indian system of human marks by Zysk (2016).

GARGASAṂHITĀ WORKGROUP 2017

A working group consisting of four members, Michio Yano, Kenneth Zysk, Bill Mak, and Marko Geslani, convened in New York at Columbia University and the Institute for the Study of the Ancient World (ISAW), New York University,

¹¹ The Sanskrit text was unpublished but a draft of the transcription is now kept in the American Philosophical Society (David E. Pingree Archive, Box 14 “DEP notes *Garga-*

saṃhitā, 1 of 2”). A summary of the remaining planetary chapters was published in Pingree 1987b.

February 20–25th, 2017. The purpose of the workgroup was to bring together scholars whose research has touched on various aspects of Garga's texts, with the hope to bring out further editions of the unpublished materials. Each member presented his materials during the week and summarized their findings in the presentations on the final day under the topics: 1) The astronomical *Gargasamhitā* in twenty chapters (Yano); 2) Emendation and transmission of the physiognomic materials in *Gārgīyajyotiṣa* (Zysk); 3) Citations of Garga in Bhaṭṭotpala's commentaries to Varāhamihira's *Bṛhatsamhitā* and *Bṛhajjātaka* (Mak); 4) Ritual in *Gārgīyajyotiṣa-Śāntikalpa* (Geslani).¹²

The following contributions from the individual participants constitute a preliminary and prospective study of a small portion of the Garga corpus.

2. TEXT CRITICAL REMARKS BASED ON THE CHAPTER ENTITLED (PURUṢA) STRĪ LAKṢAṆA (ZYSK)

My recent study of the Indian system of human marks (*puruṣastrīlakṣaṇāni*) includes a critical edition of the chapter on women's marks from the *Gārgīyajyotiṣa*, a Jyotiḥśāstra compilation that reached its final form around the beginning of the Common Era. The analysis of this material reveals certain trends in the textual transmission of Garga's text, which I should like to discuss in brief in light of the 2017 workshop on Garga.¹³

By way of introduction, I shall explain the contents of the chapter, which is included alongside chapters devoted to the marks of various types of animals (*aṅgas* 46–50). These chapters in turn form a section in Garga's overall presentation of omens. The chapter on the human marks contains verses in *anuṣṭubh* (male) and *upajāti* (female) metres in a typical structure using protases and apodoses to reveal a person's current character and future life based on a set of marks found on the human body. It follows the same method of physiognomics found in many parts of the ancient and modern world and forms an important link in the chain of transmission of this form of prognostication in antiquity.

¹² The workshop was sponsored by the Institute for the Study of the Ancient World, New York University, and is part of the Japan Society for the Promotion of Science (JSPS) Grants-in-Aid for Scientific Research (C) project #15K01118, "Overlapping Cosmologies in Pre-modern Asia" (2015–2017), supported by the "Acceleration grant for international collaboration" fund #15KK0050 (2017–2018). We would like to express our thanks to ISAW Director Alexander Jones

for his support to the workshop, as well as to those who provided to us access of the manuscript materials including Pingree's transcriptions: David J. Gary and Charles Giffen of the American Philosophical Society (Pingree archive); Kim Plofker (APS Pingree archives inventory and JH Pingree collection inventory); William Monroe and Tim Engels of John Hay Library, Brown University (Pingree collection).

¹³ See Zysk 2016: 2: 463–80.

For the purpose of this paper and as an introduction to the text of the *Gārgīya-jyotiṣa*, I shall focus on the text itself, what it reveals about the languages of the text and its transmission, and shall conclude with suggestions for further considerations.¹⁴

THE TEXT OF THE (PURUṢA) STRĪLAKṢAṆA

A total of fourteen manuscripts and two printed texts were consulted in the preparation of the critical edition of this chapter. One manuscript was not used because it was incomplete and lacked the chapter on human marks.¹⁵ Of them, six contain colophon dates, the earliest being 1825. The remaining manuscripts cannot be much older and most are later. This indicates that all the known manuscripts fall within the time-frame of most surviving Indic paper manuscripts. Although both the male and female marks are included in the manuscripts, the colophons of all but one manuscript (C) give the title of the chapter as only the system of women's marks (*strīlakṣaṇam*). This could indicate that the material on the male marks was added to female marks at a later point in time, when the colophon had already been composed. The original chapter then could have contained only the female marks and, as arranged in the surviving manuscripts, comprises merely three-and-a-half percent of the total *Gārgīyajyotiṣa*.

At first glance all the manuscript versions of this chapter exhibited in varying degrees a non-standard form of Sanskrit.¹⁶ More detailed analysis of them revealed a distinct characteristic that the study-group will verify in its ongoing study. That characteristic may be stated generally as follows: non-standard readings represent the older version, which ultimately looks back to an original that was probably composed in a form of Prakrit or vernacular language, so that the version of the text found in the manuscripts represents incomplete stages in the process of transition from non-Sanskrit to Sanskrit. Moreover, a process of Sanskritisation and Brahmanisation is traceable through different manuscript transmissions and into the scholastic traditions that cited Garga's text. For an example of such a transmission, see Appendix B below (p. 186).

Such a textual history represents what I have called a "bottom-up" transmission, beginning in a non-Sanskrit version perhaps in prose and resulting in a

¹⁴ For a detailed discussion of the contents of this chapter and its relationship to Mesopotamian and Greek systems of physiognomy and its place in the Indian system of body marks, see Zysk 2016: 1: 25–51; 55–65; 71–74

¹⁵ No. 8199 (iv) from the Asiatic Society of Bengal, corresponding to Mitchiner manu-

script J.

¹⁶ Interestingly enough, Rudolf Hoernle gave a similar description of what he called the Gāthā dialect of the Bakhshālī birch-bark manuscript on mathematics from northwestern India, in what is the Peshawar district of Pakistan (Hoernle 1888). See also Plofker, Keller, et al. 2017.

fully versified text in Sanskrit. In the batch of manuscripts I examined, no one transmission reaches the level of Sanskrit exhibited in early Dharmaśāstra, and definitely not the Sanskrit of Vahāramihira.

Emphasis is placed on producing a text in correct metre rather than following strictly the rules of Pāṇinian grammar, for it would appear that a focus on metre best characterised the stage of the transmission. A further stage is witnessed in the later reworking of the verses by traditional scholars, first by the tenth-century commentator, Bhaṭṭotpala in his commentary to the *Bṛhatsaṃhitā*, and later by the seventeenth-century *smṛti* compiler, Mitramiśra in his monumental *Vīramitrodaya*. At their hands Garga's human marks became fully integrated into the literature of Jyotiḥśāstra and Dharmaśāstra.

Proceeding from the least Sanskritic and most Prakritic version to the most Sanskritic and least Prakritic version, the manuscripts may be organized into the following four groups, which follow those of Mitchiner in his study of the *Yuga Purāṇa* chapter of Garga's compilation (*aṅga* 41). In terms of the overall manuscript, the *Yuga Purāṇa* is close to the chapter on human marks, lying about ten folia earlier, and is part of the section dealing with omens. In this way, it has many of the same features as the physiognomic chapter of my study.¹⁷ The intervening chapters of the work treat both the calls and the marks of animals.¹⁸

Group 1: Bh (Pune), R (Alwar) (very close)

Group 2: D (Bombay), C (Gujarat) (very close)

Group 3: B (Varanasi), M (Bombay) (close); E (Pune), H (Varanasi) (close); L (Calcutta), N (Calcutta), S (Varanasi) (close).

Group 4: A (Calcutta), P (Calcutta/Chandernagar), Q (Alwar).

OBSERVATIONS ON THE RELATIONSHIP BETWEEN THE MANUSCRIPTS

Based on the analysis of gaps and missing text, both indicated and not indicated in the different manuscripts, the manuscripts fall into two major groupings, corresponding to Bh and R on the one hand, and D and C on the other. A further

¹⁷ Mitchiner 2002: 30. I should point out that Mitchiner compiled a list of chapters for the whole text with his own numbering and title "*aṅga*" based on the easy-to-read and complete manuscript D (see Appendix A), originally from the library of Dr Bhau Daji in Mumbai. Pingree copied his chapter identification from Mitchiner. To my knowledge

only a single manuscript contains chapter numbers, the late manuscript C, which, moreover, is the only manuscript to divide the chapter into two separate chapters, one called *puruṣalakṣaṇa*, numbered 146 and *strīlakṣaṇa*, numbered 147.

¹⁸ For a more elaborate discussion of these divisions, see Zysk 2016: 2: 464–67.

division into sub-groups can be ascertained, so that one can speak of a primary and secondary BhR and primary and secondary DC. The primary sub-groups, called respectively, the BhR₁ group and the DC₁ group, are fairly consistent. The former includes the manuscripts corresponding to Mitchiner's group 4 (above); and the latter corresponds to his group 3 (above).

A further division into the level of the secondary groups BhR₂ and DC₂, however, is tentative, because an analysis based on variant readings rather than gaps indicates that the secondary groups are more fluid. In a significant number of cases, the readings in the secondary groups will not follow the readings in their respective primary groups, and one secondary group sometimes follows the other secondary group. A more exact formulation of the relationship of manuscripts and the establishment of a *stemma codicum* will require an analysis of a larger portion of the entire text. The 206 verses involved in this study is, however, sufficient to point to certain trends and patterns in transmission.

TRENDS AND PATTERNS

Within the primary groups, there are indications that the manuscripts are not direct copies of each other. The closest readings are found between Bh and R, while D and C show greater variation from each other, where C illustrates emendations of D. Both sets of the primary groups show closeness in readings, but it cannot yet be determined if direct copies are present among them, except in S and Q and perhaps in P and A, where the former appears to be a copy of the latter.

Since the BhR group provides the greatest number of non-Sanskrit and Prakrit readings, it has been assigned the most authentic, while the DC group illustrates the most Sanskrit readings, indicative of emendations and corrections over the course of the subsequent transmissions.

A comparison of passages from both printed editions of Bhaṭṭotpala (Yogīśvara) and Mitramiśra and select manuscripts of the former shows clear emendations when compared to the readings from the manuscripts. It is not entirely clear from the printed editions if the textual readings are editorial, but the manuscript readings of Bhaṭṭotpala (B1, B2) indicate that they are for the most part the author's emendations rather than those of the editor.¹⁹ One could presume also that the same applies to Yogīśvara's and Mitramiśra's printed

¹⁹ Yogīśvara was the author of the seventeenth-century commentary on the *Bṛhatsaṃhitā* called *Utpalapratimāla*, which, as the work's title states, is a condensed ver-

sion of Bhaṭṭotpala, especially the version of Bhaṭṭotpala found in two manuscripts from BORI, designed as B1 and B2.

texts. The textual alterations take the form of literary embellishment, grammatical corrections and, more importantly, the commentators' endeavour to use terminology appropriate to each author's Brahman-dominated intellectual milieu.²⁰ U (with Y) stays close to the DC group, while Mitramiśra (or the editor?) either follows or emends Bhaṭṭotpala.

The largest number of verses from both secondary sources occurs in the section corresponding to the *puruṣalakṣaṇāni*. Bhaṭṭotpala has twenty-four out of 111, while Mitramiśra lacks only twenty-six for a total of eighty-five verses. Both attribute the same verse to Garga, which, however, is wanting in the manuscripts. In the *strīlakṣaṇa*-section, the total number of verses from the two authors is far smaller. An examination of the two manuscripts B1 and B2 indicates that there existed discrepancy in the attribution of the verses in Bhaṭṭotpala's commentary. Because of these reasons, a critical edition of his commentary is a desideratum. Bhaṭṭotpala has seven and Mitramiśra sixteen out of ninety-five verses; and the former has two verses, 50 and 51, which are not found in the latter.²¹

It would appear that a version of the chapter on human marks in the *Gārgīya-jyotiṣa* was available as early as the tenth century. By the first half of the seventeenth century, the *puruṣalakṣaṇāni* was more established and better known than the *strīlakṣaṇāni*, since only a few verses from the former and most of the latter are wanting in the *Vīramitrodaya*. This emphasis on male physiognomy is reflected in a transmission in the later *Brhatsaṃhitā* (sixth century CE), where the verses devoted to the women's marks are far fewer than those to the men's marks, i.e., twenty-six to women versus 116 to men. The *strīlakṣaṇāni* of Garga represents the earliest comprehensive version of the female marks.

TEXT-CRITICAL OBSERVATIONS

John Mitchiner already laid the groundwork for a linguistic study of the *Gārgīya-jyotiṣa* in his critical edition and translation of the *Yugapurāṇa* which, like the chapter on human marks, forms a part of a section on omens. Even though his analysis covers only 114 *anuṣṭubh*-verses, his observations are pertinent and deserve careful consideration.²²

In addition to pointing to numerous scribal mistakes, he provides evidence in the form of phonological changes that point in the direction of a hybrid form of Sanskrit as the language of the Garga's *Yugapurāṇa*. Furthermore, he lists several

²⁰ Examples of this type of emendation can be found in the textual notes to both chapters; see Appendix B, p. 186, below. They confirm the textual emendations carried out by the later Brahmanic scholars.

²¹ Yogīśvara has far fewer verses in both sections: eight-and-a-half for *puruṣalakṣaṇa* and one for *strīlakṣaṇa*, both of which correspond to Utpala's commentary.

²² See Mitchiner 2002: 33–40.

features to indicate Prakrit influence, including (1) preservation of hiatus both at the end and in the middle of *pādas*, and (2) irregular sandhi. Taken together, these features of Garga's language imply that "the account [of the *Yugapurāṇa*] was in several cases...handed down among peoples whose one language was not Sanskrit but either Prakrit or a hybrid form of Sanskrit, and whose knowledge of Sanskrit was accordingly influenced by such further forms of language".²³

He goes on to say that he believed that the original account was rather early and written in Brāhmī script, due to the presence of *sch* for *sth* in script, a feature that originated with Brāhmī. Furthermore, he states that the work probably dates from the first century BCE to the fifth century CE, during which time, according to Franklin Edgerton, hybrid forms of Sanskrit flourished.²⁴

These observations about the language of the Garga's *Yugapurāṇa* correspond in the main to my findings for the chapter on human marks. Both the phonology and lexicography indicate influence from Prakrit and/or vernacular languages, including perhaps Buddhist Hybrid Sanskrit. The most telling example of Buddhist influence is found in the word *suajāta*, which in Sanskrit is an adjective, meaning, "well-born," "beautiful," "noble," etc. In Garga, it occurs six times only in the feminine (*suajātā*) and designates the archetypical auspicious female.²⁵ In Pāli and BHS, *suajāta*, is the name of the woman who fed the Buddha before his enlightenment. In this way, it has taken on a special significance as an apodosis, describing an auspicious woman as well born and bred with implied reference perhaps to the Buddhist story.²⁶

The other linguistic features, such as preservation of hiatus and irregular sandhi, show variation in the chapter on human marks. In the *Yugapurāṇa*, both features occur, but metre is not a contributing factor. In the chapter on human marks, there is irregular sandhi, but in most cases it takes the form of double sandhi, where the hiatus is lost rather than preserved, *metri causa*, especially in the slightly more complex *upajāti*-metre of the female marks, but also a couple of times in men's marks in *anuṣṭubh*-metre. Therefore, the differences between the two sections would include metre, where the *Yugapurāṇa* uses *anuṣṭubh* and the women's marks employs *upajāti*.

The question of Brāhmī being the script of the original version requires further investigation, since *sch* for *sth* is a common occurrence in manuscripts from north India. Therefore, a more precise determination of the original script in which the text was written necessitates the examination of a larger portion of the entire text.

23 Mitchiner 2002: 39.

24 Mitchiner 2002: 40.

25 See 2.4–5, 8, 14, 16, and 46.

26 Other examples of possible phonolo-

gic and orthographic changes and Prakrit words that were found the manuscript transmission are available in Zysk 2016: 2: 473–80.

In addition to phonological similarities to the *Yugapurāṇa* of Garga, the following grammatical and syntactical peculiarities are noticed in Garga's chapter on the human marks. Numbers 1, 3, and 4 are common to the *Yugapurāṇa*.²⁷

1. mixing of gender in the same verse
2. mixing of number in the same verse
3. double sandhi for the sake of metre
4. particular sandhi of a + vowel for the sake of metre
5. corruption of metre
6. use of instrumental to express possession
7. use of $\sqrt{dṛś}$ for $\sqrt{paś}$
8. use of the incorrect form of gerund
9. use of predictive dative.²⁸

Like the *Yugapurāṇa*, Garga's chapter on the human marks shows influence from one or more Prakrit or vernacular languages, which could reach back as far as Pāli and Buddhist Hybrid Sanskrit. Moreover, the particular evidence revealed through the manuscript transmission from the BhR group to the DC group points to a late stage in the text's transmission that aims to render material preserved in a form of Prakrit, perhaps in prose or verse, into versified Sanskrit. The manuscripts along with the printed versions of Bhaṭṭotpala's mid-tenth-century commentary and Mitramiśra's early seventeenth-century *Smṛtini-bandha* indicate a conscious process of textual emendation and translation aimed at bringing the literature into correct didactic Sanskrit verse, understandable to Brahman priests. The transmission process takes the form of rendering of material in one Indian language into Sanskrit rather than of an independent literary composition.

FURTHER CONSIDERATIONS BASED ON THE GARGA WORKSHOP

The workshop held at NYU's ISAW, organized by Bill Mak, provided the opportunity for discussions on Garga's extensive corpus and for the establishment of a working group devoted to its study. Based on the presentations from other participants the following preliminary observations deserve consideration: 1. the section called Cow Śānti offers a more correct Sanskrit text with few Prakritisms,

²⁷ See Zysk 2016: 2: 470–73.

can be found at Zysk 2016: 2: 471.

²⁸ Exact verse-references to these points

suggesting that the source text was already in Sanskrit; 2. the chapters of the *Yuga Purāṇa* and (*Puruṣa*)*strīlakṣaṇa* may therefore represent versions of material derived mainly from non-Sanskrit sources; 3. the chapter on Tithis as found in Bhaṭṭotpala's commentary to the *Brhatsaṃhitā* (printed edition) again exhibits variations from at least two manuscript versions in the form missing text and variant readings.

These observations point to a text compiled from different sources in different languages, brought together in a Sanskrit compendium and called a *saṃhitā* of the Jyotiḥśāstra. The important points to consider in the ongoing study will include an identification of the sources and their time periods as well as the original languages in which they were written. Is it possible to find extra-Indian influence in the material compiled by Garga? Finally, a major effort of the working group, we hope, will be devoted to the production of a good critical edition of the *Gārgīyajyotiṣa*, based on about fifteen, rather late manuscripts. A step in this direction will be taken in a current study of the chapter-colophons from all the available texts that in some way or other bear the name Garga. In this way, a survey of the corpus of Garga's works will emerge, giving us a better idea of the compilation of the *Gārgīyajyotiṣa* and of the other texts that go by the name of *Gargasaṃhitā*, and the relationships between them.

The mixture of languages characteristic of certain parts of the *Gārgīyajyotiṣa* raises an important question pertaining to the preparation of critical editions of such a work, and the efficacy of trying to reach the "ur-text," as commonly understood in European Indology from the late nineteenth onwards. Based on the available manuscript-witnesses of the text, the best that one could aim for is to represent aspects of the version of the text, composed in a type of hybrid language, and trace its development into Sanskrit via the manuscripts and later scholastic traditions. Crucial in such a text-critical edition is the identification and explanation of the different readings in the manuscripts. One must resist the inclination to normalize the text into correct Sanskrit. Rather one should try to find reasons for a reading as it exists in the manuscript(s), deferring to the least Sanskritic version wherever possible. Occasionally, a suitable explanation for the reading cannot be found, in which case, one must resort to the most intelligible reading, which is the one in classical Sanskrit often occurring in the versions offered by the later scholars. This is what I have endeavored to do in my edition of the chapter on the human marks.

The method of producing a critical edition of such a hybrid text permits the reader to glimpse perhaps an early stage in the evolution of Indian Jyotiṣa literature. Moreover, the hybrid nature of the language puts its source in another social class, namely, the nobility rather than the priests, whose official language was not Sanskrit but Prakrit perhaps with a mixture of vernacular languages. It seems plausible, therefore, that an early textual tradition of Jyotiṣa was known,

maintained, and transmitted by Kṣatriyas in ancient India, among whom one can include both Siddhārtha Gautama and Māhāvīra or Vardhamāna, whose followers composed religious doctrines in Prakrit languages. As in the case Buddhism and early Āyurveda, the principal early doctrines of Jyotiḥśāstra could have been transmitted through Jain communities and monasteries, among whose collections of manuscripts contain many texts in Jyotiḥśāstra, including physiognomy, known as Sāmudrikaśāstra, after the name of the India's earliest physiognomist, Samudra or Sāmudra. This hypothesis of the early history of Indian Jyotiḥśāstra will be explored further in the current studies of the Garga's works.

3. ASTRAL OMENS IN THE GĀRGĪYAJYOTIṢA (MAK)

Astral omens constitute one of the main topics, if not the most important topic, in most of the extant works attributed to Garga. Garga was referred to in the *Mahābhārata* as the *sāmvoatsara*, that is, one who has the knowledge of time, or an astronomer/astrologer.²⁹ In another passage in the *Mahābhārata*, one refers to a work of Garga in sixty-four divisions (*catuḥṣaṣṭyaṅgam*).³⁰ This description is identical to the one given in the second chapter of the *Gārgīyajyotiṣa* (G1), suggesting likely that this recension was fairly well-known and had a wide circulation.³¹ Among the sixty-four divisions or *aṅgas* of the *Gārgīyajyotiṣa* (or sixty-two according to Mitchiner, see Appendix A), a total of twenty-five of them deal with celestial omens (1–12, 20–22, 51), planetary astrology (25–29, 31–32) or astral narratives (30, 44). While these chapters as a whole show no overarching structure and appear to form an organic aggregate of subgroups of materials, some topics contain temporal and ritualistic factors which make them thematically connected to those chapters focusing on rituals (32–33, 37–38).³² The popularity of these materials is further corroborated by the long list of “vile” knowledge (*tiracchānavijjā*, literally “bestial knowledge”) refuted by the Buddha, as mentioned in the Pāli *Sāmaññaphalasutta*.³³ Rather ironically, many of the same techniques

29 MBh 12.59.117 (Śānti Parvan): *maharṣir bhagavān gargas tasya sāmvoatsaro 'bhavat*.

30 Mbh 13.18.25–26 (Anuśāsana Parvan): *gārgya uvāca / catuḥṣaṣṭyaṅgam adadāt kāla-jñānam mahādbhutam / sarasvatyās taṭe tuṣṭo manoyajñena pāṇḍava //*

31 *jyotiṣām ayanāṅgāni catuḥṣaṣṭis tathā paṭhet* (Mitchiner 1986: 102).

32 See Geslani's discussion on ritual sequence below in § 4, p. 169. Elements of this particular organizational principle are mechanically reproduced in Varāhamihira's

Brhatsaṃhitā, though not without some innovations by the latter author (See Appendix A).

33 Topics include the reading of marks on the limbs (*aṅgam nimitam*) as discussed earlier in Zysk's section on physiognomy, unusual omens such as one based on clothes bitten by mice (*mūśikacchinam*), appearance of various animals (*migapakkha*), as well as all kinds of astronomical and meteorological phenomena (Mak 2016: 139 n. 8).

were incorporated into the later Buddhist texts such as the Mahāyāna narrative *Śārdūlakarṇāvadāna* and Amoghavajra's *Xiuyao jing* 宿曜經, an eighth-century Chinese compilation of Indian astral science which had widespread influence in East Asia. The astral omens of the *Gārgīyajyotiṣa* are thus found in a variety of Indic traditions, both Brahmanic and non-Brahmanic throughout the first millennium, belonging arguably to one of the most influential astral traditions in the South Asian subcontinent in a truly pan-Indian manner.

CHARACTERISTICS OF GARGA'S ASTRAL OMENS

The astral omens of the *Gārgīyajyotiṣa* can be divided in two major groups, Vedic and post-Vedic. The Vedic astral omens are characterized by the *nakṣatras* (1, 3), while the post-Vedic ones are characterized by the planets (4–10, 25–31). As planets were never explicitly mentioned or described in the oldest Vedic corpus or Vedic astral work such as the *Vedāṅgajyotiṣa*, the inclusion of planets in the *Gārgīyajyotiṣa* places the redaction of the work to no earlier than the late Vedic period.³⁴ Among the most archaic materials in the *Gārgīyajyotiṣa*, besides those dealing with the *nakṣatras*, are those found in the chapter titled “Tithikarmaguṇāḥ,” which forms part of the first *aṅga*, titled “Karmaguṇāḥ”.³⁵ It describes the astrological characters of the fifteen *tithis*, in both the white and dark *pakṣas*. The same verses were quoted by Bhaṭṭotpala in his commentary on the corresponding section in the *Brhatsaṃhitā*.³⁶ Close parallels of this set of verses are found also in the Sanskrit *Śārdūlakarṇāvadāna*, and Amoghavajra's *Xiuyao jing*, a Chinese compilation and translation of Indian astral science dated

³⁴ There have been attempts among Indian scholars to connect Garga to the *Vedāṅgajyotiṣa*, such as the “Garga verses” Somākara cited in his commentary on the Yajur recension of the *Vedāṅgajyotiṣa*. However, as Pingree pointed out, these astronomical verses are not found in the *Gārgīyajyotiṣa* (G1) and should be dated much later (Pingree 1973: 3). The astronomical Garga verses may be comparable to those in G4 as discussed by Yano in § 5, p. 173.

³⁵ An edition of the “Tithikarmaguṇāḥ” will appear in the article Mak 2017.

³⁶ The chapter in the *Brhatsaṃhitā*, titled also “Tithikarmaguṇāḥ,” is surprisingly terse and is placed near the end of the text (chapter 98). It contains only three verses

describing the lords and names of the fifteen *tithis* (BSU 1035): *kamalaajavidhātṛ-hariyamaśaśāṇkaṣaḍvaktraśakravasubhujagāḥ / dharmaiśasavitṛmanmathakalayo viśve ca tithipatayaḥ //1// pitaro 'māvasyāyāṃ sam-jñāsadrśās ca taiḥ kriyāḥ kāryāḥ / nandā bhadrā vijayā riktā pūrṇā ca tās trividhāḥ //2// yat kāryaṃ nakṣatre taddaivatyaṣu tithiṣu tat kāryam / karaṇamuhūrteṣv api tat siddhikaraṇaṃ devatāsadrśam //3//* Utpala's quotation of Garga (BSU 1037–1039): From *nandā pratipad ity uktā praśastā dhruvakarmasu / jñānasya ca samārambhe pravāse ca vīgarhitā // ... to ... rājñāḥ purohitaṃ kuryād yajñāni vīvidhāni ca / śubhaṃ karma ca kartavyaṃ somaṃ vidyāc ca devatām //*

to 759/764 CE.³⁷ The fact that the *Gārgīyajyotiṣa* materials were transmitted beyond the Brahmanical tradition and beyond even India, highlights their popularity and tenacity. The name “Garga” (伽力伽, *jialijia*, MC. *kæ-lik-kæ*) was mentioned also in the Chinese translation of the Mahāyāna text *Mahāsaṃnipāta*, in a chapter titled *Sūryagarbha* translated by Narendrayaśas in 585 CE, as a sage who “taught the positions of *nakṣatras*, methods of long and short months and time measurements”.³⁸

GARGA’S TREATMENT OF THE PLANETS

The planets (*graha*), including the two pseudoplanets *Rāhu* and *Ketu*, are given particular prominence in the *Gārgīyajyotiṣa*, making up a series of individual chapters at the beginning of the work (2, 4–11). The presence of the nine *grahas* suggests a late Vedic formation of the text, as evidenced by the fact that planets are completely absent from both the classical Vedic corpus and the Pāli Canon. Nevertheless, the planets described in the *Gārgīyajyotiṣa* bear a number of characteristics which differentiate them from those of the later medieval tradition. These characteristics include, most strikingly, the order in which the *grahas* are presented, and their astronomical descriptions.

The nine planets (*navagraha*) in the *Gārgīyajyotiṣa* were presented in an order that cannot be easily explained: Moon, *Rāhu*, Jupiter, Venus, *Ketu*, Saturn, Mars, Mercury and Sun. As Yano observed, such unconventional order may be considered an example of the early representation of “planets with no fixed order,” as noted also in the various recensions and translations of the Buddhist *Śārdūlakarṇāvadāna*.³⁹ It should be noted that the corresponding planetary chapters in the *Brhatsaṃhitā* were reorganized to: Sun, Moon, *Rāhu*, Mars, Mercury, Jupiter, Venus, Saturn and *Ketu*. This conforms with the Hellenistic weekday order, which had become standard by the time of Āryabhaṭa in the late fifth century.⁴⁰

In what Pingree described as the type “2” variety of the *Gargasamhitā* (see above), one may note that the nine planets were neatly arranged in the Hellenistic

37 *Śārdūlakarṇāvadāna*: Mukhopadhyaya 1954: 202–3. *Xiuyao jing*: Taishō (1299) 21.393a; Yano 1986: 109 f.

38 Taishō (397) 13.282b. 《大方等大集經》「次復於後過無量世。更有仙人名伽力伽出現於世。復更別說置諸星宿。小大月法時節要略。」 See Mak 2015: 64.

39 Yano 2004: 334.

40 Since the seven weekdays in India, as in the Hellenistic tradition, do not include *Rāhu* and *Ketu*, the inclusion of the two

pseudoplanets in the *Brhatsaṃhitā* appears to be Varāhamihira’s compromised attempt to bring the Garga tradition up to date. It is of interest to note that in the Southeast Asian astral system, *Rāhu* is considered to represent the latter half of Wednesday, with the first half given to Mercury. In a more recent Northern Thai system, *Ketu* was further assigned to the latter half of Thursday, leaving Jupiter thus only to the first half.

weekday order, with the addition of the two pseudoplanets: Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, Rāhu and Ketu.⁴¹ This Hellenistic planetary order of the seven planets is attested among the early astrological texts such as the *Yavanajātaka* and the *Vṛddhayavanajātaka*, composed during the early centuries of the Common Era.⁴² Together with the two pseudoplanets Rāhu and Ketu, the *navagraha* of this particular order can only be established later, by texts such as the Grahaśānti section of the *Yājñavalkyasmṛti*, whose upper limit is the beginning of the fourth century.⁴³ The G2 recension of the *Gargasamhitā* was likely made when the orthodox *navagraha* was fully established. This thus informs us that the recension of *Gārgīyajyotiṣa* now under examination (G1) should be among the oldest, at least from the point of view of its redaction.

More importantly, and by no means better understood, are the kinds of planetary theories and descriptions in the *Gārgīyajyotiṣa* that are largely absent in the later *jyotiṣa* traditions. These include: (1) Planetary motion based on *nakṣatras* divided into various subdivisions such as “paths” (*patha*), “streets” (*vīthi*) and “circles” (*maṇḍala*); (2) Synodic phenomena, with emphasis on the duration of visibility/invisibility.⁴⁴ Varāhamihira in his *Bṛhatsamhitā* reproduced only some of these theories, with the glaring absence of the astronomical details related to planetary synodic phenomena. These unusual descriptions with no known precedents from the Indic sources led Pingree to the claim that the planetary theories in the *Gārgīyajyotiṣa* are of ultimately Babylonian origin and that *Gārgīyajyotiṣa* was “probably composed in the first (or possibly second) century A.D. ... based on material that goes back to the fourth or fifth century B.C.”⁴⁵

NEUGEBAUER AND PINGREE’S CLAIM OF A BABYLONIAN ORIGIN OF INDIAN ASTRAL SCIENCE

The idea of Babylonia as a source of ancient astral lore from various cultures is certainly not a new one, though the historical background and rationale have

41 CESS: A2: 117; Yano 2004: 335. Rāhu and Ketu are combined into one *adhyāya* (8) titled Rāhuketucāra.

42 Ketu is not found in either texts; Rāhu was mentioned only twice in the *Vṛddhayavanajātaka*, both associated with the eight directions (2.10, 2.11), as possibly an attempt to match the directions to the eight planets (7 + 1). Yano (2004) follows Pingree’s dating of the *Yavanajātaka*, which has recently been shown by the present author to be untenable (Mak 2013a,b, 2014). Since Pingree’s dating of the *Vṛddhayavanajātaka* de-

pended on that of the *Yavanajātaka*, the dating of the former is now also put in question (Mak 2014: 1103). The question of the dating of these two works cannot be satisfactorily solved until the two works are thoroughly compared both with each other and with other early *jyotiṣa* works such as Varāhamihira’s *Bṛhajjātaka*.

43 Yano 2004: 341.

44 For Venus, see Pingree 1987a: 296, 297, 305–15; for other planets, see Pingree 1987b: 95, *et passim*.

45 Pingree 1987a: 295.

been different across the ages. Starting from the Greeks, followed by the classical authors, the Chaldean – as the Babylonians were called – was often associated with the profession of an astronomer/astrologer. By the time of Ptolemy in the second century CE, Chaldea or Babylonia was thought to be one of the sources of Hellenistic astral science, motivated largely by the Greeks' desire to seek an older authority for a burgeoning new body of knowledge.⁴⁶ When European scholars came into direct contact with Sanskrit literature and Indian astral science in the eighteenth century, the Biblical idea of a common origin of languages and races, and hence by extension also knowledge, was revived in a scholarly spirit by William Jones, who claimed in 1792 that both the Indian and Greek zodiacs were transmitted from the Chaldeans, who were thought to be “the first progenitors”.⁴⁷ Such views, however, remained speculative until the Babylonian cuneiform texts, including a large collection of astronomical diaries and omen tablets, were deciphered in the nineteenth century by Epping, Strassmaier and others, who began to observe the actual relation between these materials and those of the classical antiquity.⁴⁸ Further comparative analyses between the Babylonian and Indian materials by Neugebauer and Pingree led to the bold claim that practically all fundamental concepts and methods of ancient Indian astronomy, with the exception of the *nakṣatras*, “can be traced back either to Babylonian or Greek astronomy”.⁴⁹

While a review of Neugebauer and Pingree's analyses would be beyond the scope of this report, it suffices to say that both the source materials and the methodology for their comparison leave much to be desired. To start with, the editions of both Babylonian and Sanskrit texts such as the *Enūma Anu Enlil* and the *Gārgīyajyotiṣa* are still incomplete, and the selections of materials for comparison are far from systematic, giving often false impression of resemblance. Thus, when Pingree claimed that the Mesopotamian omens were adapted into the *Gārgīyajyotiṣa* by replacing Mesopotamian months and constellations by Indian *nakṣatras* and produced a table of twenty-seven *nakṣatras* with corresponding Babylonian constellations, he gave the impression that the two systems were comparable with each other when in reality they were not – Babylonian constellations were never used for equal divisions of the ecliptic, and those thought to

46 Rochberg-Halton 1988; Rochberg 2010. As Rochberg remarked, there are, however, cases of forgeries and “[d]espite the presence of ‘Babylonian’ elements, the philosophical rationale of Greek astrology and its doctrine of interpretation are all Hellenistic Greek in origin and explainable only in terms of Greek tradition itself” (Rochberg-Halton 1988: 62)

47 Jones 1790: 369. Jones was apparently influenced by Newton as his citation of the latter's work on chronology suggests. On the intellectual milieu of the period and Jones' “ethnology project,” see Trautmann 1997: 28–30, 37–52.

48 Neugebauer 1975: 349.

49 Neugebauer 1975: 6–7.

be corresponding to the *nakṣatras* were never considered as a group, but were merely an arbitrary subset of a larger group of stars and constellations used in early cuneiform astronomical texts.⁵⁰ Similarly questionable was Pingree's comparison of Garga's descriptions of the synodic phenomena for Venus with values of a Babylonian tablet (BM 36301) which was classified by Neugebauer and Sachs as "atypical" – none of the values in fact correspond to each other and the meaning of resemblance is further reduced considering that these were likely based on the observation of the same astronomical phenomena.⁵¹ Pingree's comparison of the Venus omens with those of *Enūma Ana Enlil* was similarly selective and as Pingree himself admitted, "neither in the case of Venus nor in those of the other planets are there many exact correspondences".⁵²

A curious but challenging case of comparison is that of the *tithi*, which is featured in the *Gārgīyajyotiṣa* as we saw earlier. Pingree suggests that the Indian *tithi* is likely a concept borrowed from Mesopotamia though he admits that its origin remains obscure.⁵³ Astronomically, a *tithi* is defined as a thirtieth of a synodic month. It is an important concept not only in Indian calendrics, astrology and rituals, but also in Indian astronomical computation as a fundamental unit (see *Vedāṅgajyotiṣa*); it was later established as one of the five components of traditional Indian calendar (*pañcāṅga*).⁵⁴ In the Indian context, it was likely conceived originally as a means to keep track of the phases of the Moon.⁵⁵ Inconvenient as it is (63/64 of a day), the *tithi* is nonetheless a useful device as it is based on the mean synodic month, disregarding its actual varying length due to the Moon's anomalistic movement.⁵⁶ Most likely for the same reason, the same principle was adopted in the Babylonian lunar tables, although the unit was never spelt out explicitly and was referred to as "days" in Babylonian texts.⁵⁷ Beside the lack of a specific designation, the concept of *tithi* itself has no counterpart in Babylonian sources in terms of astrological or ritual applications, and was never used for astronomical computation in any fundamental way. In the case of Hellenistic astral science, there has so far been no evidence of any concept comparable to *tithi* at all.⁵⁸

⁵⁰ Pingree 1987b: 295–6; with twenty-eight *nakṣatras*, Pingree 1989: 442. I thank John Steele of Brown University for providing me the references to the Babylonian sources and the more recent studies of the materials.

⁵¹ Pingree 1987b: 311–5.

⁵² Pingree 1987a: 91.

⁵³ Pingree 1963: 231.

⁵⁴ Plofker and Knudsen 2011: 61.

⁵⁵ Plofker and Knudsen 2011: 62.

⁵⁶ The *tithis* in the early and some classical *jyotiṣa* texts are of fixed mean length, but became of variable length as thirtieths of the true synodic month (Neugebauer 1957: 186 f., fn. 2).

⁵⁷ Neugebauer 1957: 128, 1975: 349, 358, 360.

⁵⁸ Neugebauer 1957: 186. It is all the more curious that the *tithi* was described in the *Yavanajātaka* as the "soul" (*jīva*) of the prin-

Despite the limitation of the sources and the methodological issues of comparison, and despite the assertions of Pingree and Neugebauer, the question of Babylonian influences on early Indian astral works such as the *Gārgīyajyotiṣa* remains an open one. Rather than admitting or denying wholesale the influence of Greco-Babylonian astral tradition on its Indian counterpart, the picture that is gradually emerging from our study is a much more nuanced one. In other words, to what extent were Babylonian, Greco-Babylonian and Hellenistic astral sciences transmitted and absorbed into the early *jyotiṣa* tradition, and to what extent were there local development and innovations, appear to the questions we will continue to ask. To answer them in any satisfactory fashion from at least the Indian side, a complete edition of the *Gārgīyajyotiṣa*, followed by an annotated translation, would be the first and necessary step. The grand desideratum would be a thorough comparative study of the extant early *jyotiṣa* materials, including the *Gārgīyajyotiṣa*, the *Vedāṅgajyotiṣa*, the Buddhist and Jaina astral texts, the *Vṛddhayavanajātaka* and the *Yavanajātaka*, as well as works up to the time of Varāhamihira.

4. GARGA, VARĀHAMIHIRA, AND EARLY HINDU RITUALS (GESLANI)

Already in 1910, George Melville Bolling, one of the editors (along with Julius von Negelein) of the *Atharvavedaparīṣiṣṭas*, noted the close textual relationship between Garga, Varāhamihira, and the *Atharvavedaparīṣiṣṭas*.⁵⁹ In light of this long-recognized connection between Jyotiḥśāstra and late-Vedism, I will here outline Garga's potential for triangulating the formative period of Hindu ritual.

Varāhamihira's text corpus presents an important resource for the study of this period. The *Brhatsaṃhitā* alone contains, in addition to our earliest datable prescription for image installation (*pratiṣṭhā*), instructions for a number of important royal rituals, including the festival of Indra's banner (*indradhvaja*), lustration of war animals (*nīrājana*), and a royal consecration, the "Puṣya-bath" (*Puṣyasnāna*). Together, these four rituals recapitulate a major portion of what would,

ciples of time measurements, YJ 79.6 (Mak 2013a: 90; note Pingree emended *jīvam* to *bījaḥ* and translated *tithi* as "seed"). The fact that *tithi* was not only stated explicitly in the text but was used as a fundamental unit for astronomical computation poses a severe challenge to Pingree's claim that the text was a versification of a Greek prose ver-

sion of the text composed in Alexandria. Both Neugebauer and Pingree seem to suggest that there is a lost Hellenistic tradition preserved in the Sanskrit materials.

⁵⁹ Bolling 1910: 125. For the edition of the *Atharvavedaparīṣiṣṭas*, see Bolling and Neglein 1909.

<i>Ritual</i>	<i>Timing</i>	<i>Bṛhatsaṃhitā chapter</i>
<i>indrādhvaja</i>	śukla bhādrapada	42
<i>nīrājana</i>	śukla āśvina	43
<i>yātrā</i>		
<i>puṣyasnāna</i>	various	47
<i>pratiṣṭhā</i>	uttarāyana	59

Table 4: Ritual Sequence according to the *Bṛhatsaṃhitā*.

by the medieval period, become the “Hindu” calendar, which balances rituals of warfare in the fall with rituals of pious public works in the spring (see Table 4). The central pivot of this scheme was the military campaign (*yātrā*), which Varāhamihira details in separate texts having the title “Yātrā”.⁶⁰ While the prescribed timing of the *Puṣya*-bath varies, its placement in the structure of the *Bṛhatsaṃhitā* suggests a royal re-consecration upon returning from the military campaign. Many of these royal rituals of course predate Varāhamihira, with prescriptions occurring in late-Vedic texts. But his inclusion of *pratiṣṭhā* marks an important turn towards later medieval forms of temple-based Hinduism.

In addition to his calendrical organization, Varāhamihira also displays systematic and detailed knowledge of ritual technique. The ritual prescriptions of the *Bṛhatsaṃhitā*, especially, skillfully combine the techniques of *bali*, *homa*, and *pūjā* on the one hand, and Vedic and non-Vedic mantras on the other. This again marks Varāhamihira’s transitional status between Vedic and Hindu ritual. A study of these ritual chapters, together with those of his *yātrā*-texts, points to the likelihood that the *śānti*-based rituals of the late-Atharvaveda formed one important source for Varāhamihira’s ritual.⁶¹ This is on the surface not surprising, since the Atharvaveda formed the main repertoire of the royal *purohita*, and both Atharvan and *jyotiṣa* sources idealize the partnership between the *purohita* and the astrologer.⁶² Nonetheless, the practical correspondence is rather striking when viewed from the level of ritual texts. A close comparison of Varāhamihira’s account of the *yātrā* with the structure of the *Atharvavedaśāntikalpa* (supplemented by chapters from the *Atharvavedapariśiṣṭas*), yields parallels both in ritual content, sequence, and technique (see Table 5). It is not surprising then, that versions of the major royal rituals of the *Bṛhatsaṃhitā* including the *Indrādhvaja*, *Nīrājana*, and *Puṣyasnāna* (*abhiṣeka*) are also found among the *Atharvavedapariśiṣṭas*.⁶³

60 In three versions: *Bṛhadyātrā*, *Yogayātrā*, and *Tikanikayātrā*.

61 Geslani 2016.

62 See Geslani forthcoming.

63 See AVPŚ 19, 17–18b, 5, respectively.

Ritual/Deity Group	<i>Br̥hadyātrā</i> (ch)	<i>Yogayātrā</i> (ch)	<i>Śāntikalpa</i> (ch)
<i>Lokapāla</i>	17.4cd	6.1–18	2.14
<i>Guhya</i> / <i>Vināyaka</i>	17	6.19–28	1.3–9
dream (<i>svapna</i>)	18	6.29	AVPŚ 68
clay bath	4.19–23	7.13–15	1.5–6
<i>Nakṣatra</i> / <i>Vijayasnāna</i>	19	7.1–12	2.1–12 / AVPŚ 1
(<i>Nava</i>) <i>graha</i>	20	6.1–18	1.10–18
<i>homa</i> (with <i>mantragaṇas</i>)	21.1–7	8.1–7	2.24
fire divination	21.8–10	8.8–19	AVPŚ 24 / 29

Table 5: Ritual Parallels in Varāhamihira's Yātrā and the *Atharvavedaśāntikalpa* (Geslani 2016: 319).

Although important aspects of the Atharvan system must have predated Varāhamihira, the full historical process whereby Varāhamihira came to produce his ritual system remains somewhat opaque.⁶⁴ The text of the *Gārgīyajyotiṣa*, however, may shed considerable light on this process. A perusal of the chapter colophons provided by Mitchiner reveals a number of potentially parallel rituals with the above Atharvan and Jyotiḥśāstric sources (Appendix A). These include Aṅga 32 (Yātrā); Aṅga 33 (Agnivārṇa), which contains a section on *agninimitta* (see YY 8/BY 21); Aṅga 37 (Balyupahāra), which, like Varāhamihira's *yātrā*-texts comprises a general balyupahāra (see YY 6/BY 17) and a separate *nakṣatrabalyupahāra* (see YY 7/BY 19); Aṅga 38 on *Śāntikalpa*; and Aṅga 44 on *Indradhvaja* (see BS 43/AVPar 19). The text also contains large sections on omens, a topic closely related to *śānti* rituals.⁶⁵

If, as it seems, the extant text was indeed a source for Varāhamihira, a comparative study of these chapters may shed light on numerous issues.⁶⁶ First, an edition of Garga would place us in a better position to assess how Varāhamihira's ritual corpus was assembled. To what extent were Varāhamihira's ritual calendar and technique derived from earlier sources? How innovative was his

64 While there is so far no final consensus on the relative dating of the texts as we have them, especially given the apparently composite nature of some of the *Atharvavedapariśiṣṭas*, most scholars support taking Varāhamihira as an end date for the ancillary texts of the Atharvaveda. See Einoo 2005: 13; Geslani 2016; Yano forthcoming. See Bischof and Griffiths 2003 for an overview of

the dating of the *Atharvavedapariśiṣṭas*.

65 See Kumagai 2007, 2011, 2015. An appendix of the *Gārgīyajyotiṣa*, *Mayūracitraka*, forms an alternate *utpāta* chapter also containing *śānti* rituals.

66 The *Nakṣatrakarmaguṇa* corresponds at least to Bhaṭṭotpala's quotations of Garga in his commentary to the *Br̥hatsaṃhitā*. See § 3, p. 163, above.

ritual system? For example, Garga's chapter on *Indradhvaja* occurs after the *Yātrā*, which does not reflect Varāhamihira's calendrical ordering. From such an angle, Varāhamihira appears to be an innovator. Furthermore, all of the rituals in the *Brhatsaṃhitā* (including the *Indradhvaja*) follow the *bali*-based ritual system of the *yātrā*, which suggests that the military march provides important ritual conventions for other royal rites. Does the same relationship obtain in Garga? A study of both the *Indradhvaja* and *Yātrā* chapters of Garga might thus place the relative novelty of Varāhamihira's ritual construction in clearer perspective.

Second, Garga may shed light on the early landscape of *śānti* rituals beyond the influential forms from the Atharvaveda. Are parts of Atharvan *śānti* rituals attested in Garga? Or does Garga draw from other ritual actors and techniques? A preliminary estimate of Garga's *Śāntikalpa* reveals few parallels with its Atharvan counterpart. Unlike the Atharvan *Śāntikalpa*, which is highly structured, Garga's text combines at least three separate ritual prescriptions in verse and prose. Preliminary impressions reveal nearly no overlap between the two *śāntikalpas*.

Atharvaveda Śāntikalpa *Gārgīyajyotiṣa Śāntikalpa* (Mitchiner 1986: 108)

i. Vināyaka	i. gavāṃ śānti
ii. Navagraha	ii. janamāraśānti
iii. Nakṣatra	iii. janamāraśāntike dvitīyaḥ paṭalaḥ
iv. Lokapāla	iv. janamāraśāntiprakaraṇaṃ
v. Nirṛti	v. kālajñāne śāntikalpaḥ
vi. Mahāśānti	

The first (verse) prescription, for example, concerns the appeasement of ten forms of cow-disease, rather than the broader class of omens (*utpāta*) to which *śānti* rites are usually addressed.⁶⁷ The ritual combines techniques of *bali*, *homa*, and *dhūpa*. While these techniques depart from the aspersion-based format of the Atharvaveda, they fit within the broader ambit of "*pariśiṣṭa*-level" of rituals described by Shingo Einoo, which he characterized as a transitional stage between Vedic and later Hindu (Purāṇic and Tantric) forms.⁶⁸ This is especially evident in the prescription of various species of kindling woods (*samidhs*) as offerings in the sacrifice, which may have been a non-Atharvan, but still Vedic, alternative for *śānti*. For example, in order to remove (*vimokṣaṇe*) the so-called Kālīṅga disease,

⁶⁷ As in AVPŚ 64 and BS 45, chapters on *utpāta*. The *Atharvavedapariśiṣṭas*, however, also feature a short tract on *Gośānti*

(AVPŚ 66).

⁶⁸ Einoo 2005.

one is instructed to perform a *homa* offering with kindling sticks (*samidhaḥ hotavyāḥ*) of *āśvattha*, *uḍumbara*, and *khadira*, along with ghee. As Einoo shows, the use of *samidhs* as the direct object of the fire offering in this way is an innovation of *pariśiṣṭa*-level texts.⁶⁹

The two other *śānti*-prescriptions in Garga's *Śāntikalpa*, being mostly prose compositions, are more corrupt in the manuscripts examined so far, but they seem to share a similar ritual orientation, while also citing Vedic (non-Atharvan) mantras. Further manuscript evidence will hopefully clarify these ritual actors and techniques.

5. THE GARGASAṂHITĀ: ONE OF THE TEXTS OF JYOTIḤŚĀSTRA ASCRIBED TO GARGA (YANO)

When I visited Brown University in 1973–4 as a research fellow of the Japan Society for the Promotion of Science, I learned the fundamentals of editing Sanskrit manuscripts on astronomy and astrology from David Pingree. He was interested in the different texts that bore the name *Gargasaṁhitā* (hereafter GS), so we began examining a manuscript by that name from VVRI, mentioned in his *Census of the Exact Sciences in Sanskrit*.⁷⁰ Every week I transcribed the manuscript directly from the microfilm reader in my notebook and prepared an English translation. Pingree was very careful to correct my edition and translation. My notebook with Pingree's corrections with red pencil is the most memorable and valuable evidence of Pingree's affection for his student. At the end of the academic year we nearly completed the manuscript. I regret, however, that after I returned to Kyoto I did not continue the work. Now nearly after forty years, thanks to the Garga working group, I am able to return to the work. The following is my current thoughts and understanding of the text.

Unlike the *Gārgīyajyotiṣa*, this *Gargasaṁhitā* (G4) assumes the style of a Purāṇa-text, in which the information on jyotiṣa unfolds in the form of a conversation between of Garga with Bharadvāja. The exact date of the text is uncertain but from its astronomical theory and parameters it is definitely after the *Brāhmasphuṭasiddhānta* (BSS) of Brahmagupta (6–7th century). There are still many lines which are unintelligible, but the text itself is very interesting from the point of the history of astronomy and mathematics. In this article I would like to offer only a summary of the contents, from which both its relationship to the *Gārgīyajyotiṣa* and its uniqueness in the Indian tradition of Jyotiḥśāstra can be ascertained.

Here is a table of contents of GS consisting of 20 chapters.

⁶⁹ Einoo 2005: 41–9.

⁷⁰ CESS: A2, 118.

1 <i>Kālasvarūpavidhāna</i>	9 <i>Grahasphuṭīkarma</i>
2 <i>Puruṣakṛtyādisṛṣṭividhā</i>	10 <i>Jīvāprakalpana</i>
3 <i>Sakalajagadgrahasṛṣṭividhāna</i>	11 <i>Laghusphuṭāvihāna</i>
4 <i>Mṛtyugraha cakravādhāna</i>	12–16 No titles are given.
5 <i>Graha kaṣyādibhagaṇotpattividhāna</i>	17 <i>Chāyāvidhāna</i>
6 <i>Grahamadhyavidhāna</i>	18 No title is given.
7 <i>Jīvājanma</i>	19 <i>Sūryagrahaṇa</i>
8 <i>Jīvāvidhā</i>	20 <i>Chedaka</i>

Although the main topic is mathematical astronomy, our text begins with cosmology of the Purāṇic nature. Probably the author put the name of Garga in order to make it appealing to the reader. The first four chapters of this text are intended to show this guise. Actually Chapter 5 is the beginning of the main topic of this text, namely, mathematical astronomy.

CHAPTERS 1–4

The topic of the first chapter is time. The time shorter than *nimeṣa* is further divided in the following way:

$$\begin{aligned}
 1 \text{ laghu} &= 1/5 \text{ nimeṣa}, \\
 1 \text{ tatpara} &= 1/6 \text{ laghu}, \\
 1 \text{ maṇḍana} &= 1/10 \text{ tatpara}, \\
 1 \text{ truṭi} &= 1/10 \text{ maṇḍana}, \\
 1 \text{ daṁśaka} &= 1/5 \text{ truṭi}, \\
 1 \text{ saṁkalita} &= 1/20 \text{ daṁśaka}.
 \end{aligned}$$

The time units longer than *nimeṣa* are essentially the same as Brahmagupta's (BSS 1.12c–13b).

In GS 2.17,⁷¹ the size of Prakṛti is given as

$$94, 927, 039, 815, 168, 600, 000, 000, 000 \text{ yojanas.}^{72}$$

The argument is based on the Sāṁkhya philosophy. The circumference of Brahmāṇḍa is $1/10^7$ (*koṭyaṁśa*) of that of Prakṛti (GS 2.15), that is,

⁷¹ The numbering of verses is my own.

⁷² Expressed as *khaikādaśa-rtu-nāga-ṣaṭ-ku-śara-indu-nāga-go-vahni-kha-*

aga-yugala-aṅka-samudra-gāva.

This is based on the so-called *bhūtasam-khyā* system of expressing numbers.

<i>Loka</i>	<i>Height</i>	<i>Width in yojana</i>	<i>Residents</i>
1. Satya	6 <i>koṭis</i>	16,000	Prabhu
2. Tapar	4 <i>koṭis</i>	16,000	Vairāja
3. Jana	2 <i>koṭis</i>	16,000	Dakṣa
4. Mahat	1 <i>koṭi</i>	32,000	Deva, Asura, Indra, Hiraṇya etc.
5. Svarga	30 <i>lakṣas</i>	32,000	Siddha and Apsaras
6. Bhuva	1 <i>lakṣa</i>	12,000	Yakṣa, Gandharva, Kinnara
7. Vasudharā		100,000	man, Sarit, Parvata, Samudra etc.

Table 6: The dimensions of the seven worlds.

<i>Continents</i>	<i>Oceans</i>	<i>Size in lakṣa</i>
Jambu	Lavaṇa	1
Plakṣa	Ikṣu	2
śālmālī	Saurā	4
Kuśa	Sarpis	8
Krauñca	Dadh	16
Śāka	Dugdha	
Puṣkara	Jala	64

Table 7: The sizes of seven continents and seven oceans.

9, 492, 703, 981, 516, 860, 000 *yojanas*. This is nearly ten times of the circumference of the sky (C_k) which is later mentioned in Chapter 5. The diameter of Mt. Meru at its base is 16, 000 *yojanas* and at its peak 32, 000 *yojanas*. Its color corresponding with four *varṇas* are: east – white (brahmin), south – yellow (vaiśya), west – black (śūdra), north – red (kṣatriya). Around Meru there are four mountains, viz., Mandana (E), Gandhamāla (S), Vipula (W), and Supārśva (N), each 10, 000 *yojanas* high. Each mountain has a huge tree of 1100 *yojanas* high, viz. Kadamba (E), Jambū (S), Pippala (W), and Vaṭa (N).

In chapter 3 the dimensions of the seven worlds are given as in Table 6.

The sizes of seven continents and seven oceans are standard Purāṇic ones. See Table 7.

Seven underworlds (*pātālas*) are also mentioned, but some numbers are missing; see Table 8.⁷³

⁷³ See Kirfel 1920: 144.

<i>Name</i>	<i>Distance from the preceding</i>	<i>Distance from Meru</i>
1. Atala	100,000	10,000
2. [Vitala?]	200,000	56,000
3. [Nitala?]	[400,000]	[??]
4. Gabhasmat	800,000	[??]
5. Mahita	1,600,000	40,000
6. Sutala	3,200,000	32,000
7. Pātāla	6,400,000	16,000

Table 8: Seven underworlds (*pātālas*).

In chapter 4 mythological accounts of planets are given: Kāmī and Chāyā as wives of the Sun, Tārakā as the wife of the Moon, and Mercury is the son of Tārakā and the Moon. As in the astronomical texts, the Sun is the *śiḡhra* of Jupiter, Mars, and Saturn. Mercury and Venus are themselves *śiḡhra*. The weekday order of planets is presupposed, which is based on the concentric order: Moon, Mercury, Venus, Sun, Mars, Jupiter, and Saturn. Beyond planets are *nakṣatras*, Saptarṣis, and the pole star (in this order, GS 4.49).

CHAPTER 5

As I said above, this chapter is the beginning of mathematical astronomy. Thus it begins with the names of decimal places.

The following names are listed (GS 5.5–9):

<i>eka</i> ,	<i>arbuda</i> (10^8),	<i>antya</i> (10^{16}),	<i>atikharva</i> (10^{24}),
<i>daśa</i> (10^1),	<i>abda</i> (10^9),	<i>parārdha</i> (10^{17}),	<i>atinikharva</i> (10^{25}),
<i>śata</i> (10^2),	<i>kharva</i> (10^{10}),	<i>atyayuta</i> (10^{18}),	<i>atimahāpadma</i> (10^{26}),
<i>sahasra</i> (10^3),	<i>nikharva</i> (10^{11}),	<i>atilakṣa</i> (10^{19}),	<i>atiśaṅkha</i> (10^{27}),
<i>ayuta</i> (10^4),	<i>mahāpadma</i> (10^{12}),	<i>atiprayuta</i> (10^{20}),	<i>atisindhū</i> (10^{28}),
<i>lakṣa</i> (10^5),	<i>śaṅku</i> (10^{13}),	<i>atikoṭi</i> (10^{21}),	<i>atimadhya</i> (10^{29}),
<i>prayuta</i> (10^6),	<i>samudra</i> (10^{14}),	<i>atyarbuda</i> (10^{22}),	<i>atyanta</i> (10^{30}),
<i>koṭi</i> (10^7),	<i>madhya</i> (10^{15}),	<i>atyabda</i> (10^{23}),	<i>atiparārdhya</i> (10^{31}).

GS 5.31–50 gives the circumference of planetary orbits (C_i) as shown in Table 9. Corresponding numbers of diameter (D_i) are also given, but strangely all the numbers of the ratio C_i/D_i are slightly different. According to *Āryabhaṭīya* 1.6 moon's circumference in *yojana* is ten times of its circumference in minutes, thus, $360 \times 60 \times 10 = 216,000$ *yojanas*. For Brahmagupta (BSS 21.11) it is 15 times,

	C_i	R_i	$C_k = C_i \times R_i$
Moon	16,436,640	57,753,312,000	949,270,398,151,680,000
Mercury	52,921,328	17,937,388,000	949,270,398,811,264,000
Venus	135,180,646	7,022,236,000	949,270,378,844,456,000
Sun	219,738,518	4,320,000,000	949,270,397,760,000,000
Mars	413,289,052	2,296,868,000	949,270,398,289,136,000
Jupiter	2,606,568,103	364,184,000	949,270,398,022,952,000
Saturn	6,475,948,249	146,584,000	949,270,398,131,416,000

Table 9: The circumferences of planetary orbits (C_i).

	C_i	R_i	$C_k = C_i \times R_i$
Moon's manda	1,944,736,057	488,123,000	949,270,398,351,011,000
Moon's pāta	4,086,293,071	232,306,000	949,270,398,151,726,000
Mercury's manda	5,103,604,264,256,345	186	949,270,393,149,820,170
Mercury's pāta	3,451,892,025,386,955?	275	949,270,306,706,412,???
Venus' manda	2,816,826,107,275,015	337	949,270,398,151,679,718
Venus' pāta	2,551,802,145,526,90?	372	949,270,398,036,006,80?
Sun's manda	551,913,942,742,326?	1,632??	900,723,554,555,476,032?
Mars' manda	3,528,886,238,482,082	269	949,270,398,420,680,058
Mars' pāta	9,786,292,764,430,309	97	949,270,398,149,739,973
Jupiter's manda	4,295,341,168,107,127	221	949,270,398,151,675,067
Jupiter's pāta	4,893,146,382,225,155	194	949,270,398,151,680,070
Saturn's manda	6,286,558,928,156,821	151	949,270,398,151,679,971
Saturn's pāta	[3,502,842,797,607,675]	271	—————

Table 10: Apogee and node.

i.e., $360 \times 60 \times 15 = 324,000$ *yojanas*. What Garga gives as C_i of the moon is quite different from those of astronomical texts. Rotations (R_i) of planets in a Kalpa are given in GS 5.58–66 as listed in the third column of Table 9. For all the planets $C_k = C_i \times R_i$ should be same, because the linear motions of all the planets are same, but strangely we find slight differences in this list.

The astronomical *manda-ucca* (apogee) and *pāta* (node) are treated just like the planets.

Something is wrong with Mercury's *pāta* and Sun's *manda*. C_i of Saturn's *pāta*

is not given in the text. The number above was computed by $C_k/271$.

As mentioned above 'Brahman's orbit' (*brahmāṇḍakakṣyā*) is

$$9,492,703,981,516,860,000 \text{ yojanas}$$

which is ten times C_k . Since the civil days in a Kalpa are

$$1,577,917,440,000 \text{ (GS 5.71),}$$

Brahman's daily motion is

$$\frac{9,492,703,981,516,860,000}{1,577,917,440,000} = 601,597 \text{ yojanas,}$$

the number being exactly what Garga says in GS 5.55.

According to BSS 21.11,

$$C_k = 18,712,069,200,000,000 \text{ yojanas.}$$

I do not know why Garga made it about 500 times as large.

In the following I would like to give some examples of mathematical astronomy.

CALENDAR ELEMENTS IN A KALPA (GS 5.68–73)

Solar years (S)		= 4,320,000,000
Sidereal days (B)		= 1,582,237,440,000 (GS 5.71)
Solar months (M_s)	= $S \times 12$	= 51,480,000,000 (GS 5.72)
Lunar months (M_m)	= $R_m - S$	= 57,753,312,000 – S
		= 53,433,312,000
<i>Adhimāsas</i> (A)	= $M_m - M_s$	= 1,593,312,000 (GS 5.73)
Civil days (D)	= $B - S$	= 1,577,917,440,000
<i>Tithis</i> (T)	= $30 \times M_m$	= 1,602,999,360,000
Omitted days	= $T - C$	= 25,081,924,000 (GS 5.73)
Therefore, 1 year	= D/S	= 6;5;15,31,12 days
1 lunar month	= D/M	= 29;31,50,9,9... days
Mean daily motion of the Sun	= $S \times \frac{6;0}{D}$	= 0;59,8°

CHAPTER 6

GS 6.8–11ab gives a standard method of computation of *ahargaṇa* (accumulated days since epoch). According to BSS 1.26,27 the elapsed years since the beginning of the present Kalpa until the end of Dvāpara are:

$$\begin{aligned}
6 \text{ Manus} &= 71 \times 6 \text{ (caturyugas)} \\
&\quad + 27 \text{ caturyugas} \\
&\quad + 3 \text{ yugas (= } 9/10 \text{ caturyugas)} \\
&\quad + 7 \text{ sandhis (} 4/10 \text{ caturyugas)} \\
\text{total: } 453 + 9/10 + 28/10 &= 4567/10 \text{ caturyugas} \\
&= 4567 \times 432,000 \\
&= 1,972,944,000 \text{ years.}
\end{aligned}$$

According to Garga,

$$\begin{aligned}
6 \text{ Manus} &= 71 \times 6 + 28 = 454 \text{ (caturyugas)} \\
&\quad + 3/4 \text{ caturyugas} \\
\text{total: } 454 \text{ } 3/4 \text{ caturyugas} &= 1,964,520,000 \text{ years.}
\end{aligned}$$

Garga gives the longitudes of apogee (GS 6.33–35) and *pāta* (GS 6.36–38) of planets. They can be compared with those in the *Pañcasiddhāntikā* of Varāhamihira.

In GS 6.65–74 Garga gives the rotations of planets in a *Yuga* instead of *Kalpa*, thus $1/1,000$ of the numbers of R_i in Table 4 above. According to GS 6.74 ‘the rotations of the *nakṣatras* (in a *yuga*) are 200’. In a *Kalpa* $R_i = 200,000$. Therefore its orbit is $C_i = C_k/200,000 = 4,746,351,990,758$ *yojanas*.

CHAPTER 7

Derivation of 36 Sines is described in detail. The radius = 3438, the standard value used by Āryabhaṭa.

Starting from $\sin 90^\circ$ (36th), 4 Sines in total. ($\sin 90^\circ, 45^\circ, 22.5^\circ, 77.5^\circ$)

Starting from $\sin 30^\circ$ (12th), 8 Sines in total. (12th, 24th, 6th, 30th, 3rd, 33rd, 15th, and 21st)

Starting from $\sin 10^\circ$ (4th), 24 Sines in total.

CHAPTER 8

In this chapter Garga gives the values of Sines and versed Sine. Here are 36 values of Sines in a quadrant at the interval of $2^\circ 30'$. The standard Sine table initiated by Āryabhaṭa gives 24 values in a quadrant at the interval of $3^\circ 45'$. I have never seen a table with 36 entries. In chapter 10 Garga provides a concise Sine table, where 12 values are given at the interval of $7^\circ 30'$. This is closely related with the standard Sine table and can be compared with Āryabhaṭa's.

CHAPTER 9

Just like Āryabhaṭa, Garga thinks that the size of epicycles changes according to the quadrant.

CHAPTER 10

A concise Sine Table with Radius = 3438 is given. All the 12 values are same as those of Āryabhaṭa, except $\text{Sin } 67;30^\circ = 3178'$ where Āryabhaṭa gives 3177'.

CHAPTER 11

The number of *manda* equations and that of *śīghra* equations are given at the interval of $7;30^\circ$. They can be compared with those of astronomical texts in the corresponding tables in Pingree's survey.⁷⁴

CHAPTER 13

The fast apogee (*śīghra-ucca*) and the slow apogee (*manda-ucca*) are used to explain the two kinds of irregular motions of planets. They can be explained by means of epicycles or eccentric circles. Synodic arcs of the five planets are described in this chapter.

CHAPTER 14

The longitudes of the *yogatārā* or the chief star in the *nakṣatra* are given. Similar tables are found in Brahmagupta's BSS Chapter 10,⁷⁵ *Khaṇḍakhādya* 9.4–5,⁷⁶ and Bhāskara I's *Mahābhāskarīya* 6.62–71.⁷⁷ Bhāskara I's values are in ecliptic longitude. Garga's numbers may be in ecliptic longitudes, while Brahmagupta gives them in polar coordinates (polar longitude and polar latitude).

CHAPTER 16

Maximum latitudes in minutes are given as follows.

Moon	270'	=	4;30°,
Mars	90	=	1;30,
Mercury	9	=	1;30,
Jupiter	6	=	1;00,
Venus	12	=	2;00,
Saturn	12	=	2;00.

⁷⁴ Pingree 1978: 587 (for Brāhma-pakṣa),
625 (for Gaṇeśa-pakṣa).

⁷⁵ Pingree 1978: 565–7.

⁷⁶ Chatterjee 1970.

⁷⁷ Shukla 1960.

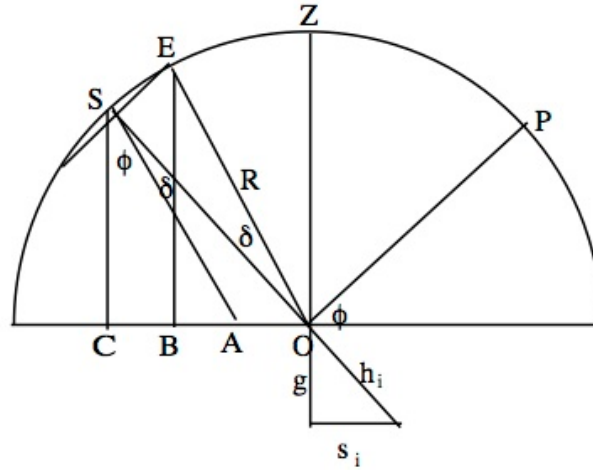


Figure 1: Great shadow at noon.

CHAPTER 17

The topics in this chapter are usually dealt with in a chapter called *Tripraśnā-dhyāya* in astronomical texts.

Here are only a few examples out of many interesting ones.

R radius of the great circle

g gnomon of the length 12 *aṅgulas*

φ geographical latitude

λ longitude of the sun

ε greatest declination of the sun

δ declination of the sun

h₀ equinoctial noon hypotenuse

s₀ equinoctial noon shadow

$$\text{GS 17.6 } h_0 = \sqrt{g^2 + s_0^2}$$

$$\text{GS 17.7 } s_0 = \sqrt{h_0^2 - g^2}$$

$$\text{GS 17.8 } \sin \phi = \frac{R \times g}{h_0}$$

$$\text{GS 17.12 } OC = \frac{R \times s_i}{h_i} = \text{mahatī (prabhā) (Great shadow at noon; see Fig. 1)}$$

$$\text{GS 17.14 } \sin \lambda = \frac{\sin \delta \times R}{\sin \epsilon}$$

CHAPTER 18

This chapter deals with the conjunction of planets. GS 18.3 says ‘The Moon is the obscurer of all the planets and *nakṣatras*.’

CHAPTER 19

On solar eclipses. Longitudinal and latitudinal parallaxes are main topics. Lunar eclipses are briefly dealt with in Chapter 20.

CHAPTER 20 CHEDAKA

The topic is usually called *chedyaka*, or graphical representation of the three dimensional objects on to a plane surface. In this chapter, only the cases of eclipses are described. Similar topic is found in Brahmagupta’s *Khaṇḍakhādyaka*, Chapter 13.

6. CONCLUSION (GESLANI, MAK, YANO, ZYSK)

Altogether, the contributions above confirm the importance of Garga not only for the history of Jyotiḥśāstra, but also for the broader cultural history of ancient and medieval India. A sense of this broad relevance may be captured by summarizing our view of the issue of dating and chronology.

Our preliminary impressions tend to confirm that the *Gārgīyajyotiṣa* (G1) presents a formative phase of the Jyotiḥśāstra tradition best represented by the works of Varāhamihira. This is seen, for example, in Zysk’s presentation of evidence of Prakritisms in the manuscripts of the *strī(puruṣa)lakṣaṇa* chapter, Mak’s observation of the non-standard order of Garga’s account of the planets, and Geslani’s comments on the relative lack of system in the ritual *aṅgas*. Thus while the *Gārgīyajyotiṣa* shares an overwhelming amount of material in common with Varāhamihira’s *Bṛhatsaṃhitā* (among other works), the text on the whole gives the impression of being a somewhat less organized and more fluid stage of the Indic astral sciences. Moreover, Garga’s text offers a significant amount of information not found in Varāhamihira’s treatise.

This chronological situation on its own has tended to inspire two general areas of focus. On the one hand, both in his article, “Venus Omens in India and Babylonia,” and in his other discussions, Pingree focused on determining the ancient, originally non-Indic, sources of the *Gārgīyajyotiṣa*.⁷⁸ While somewhat critical of the uni-directional nature of Pingree’s work, Zysk has more recently

⁷⁸ Pingree 1987b.

pursued a similar line of inquiry by comparing Garga's chapters on the human marks to Mesopotamian and Greek physiognomic systems, revealing significant similarities. Thus, while accepting the dating of the text to the early centuries CE, this first perspective also looks backward, to the miscellaneous, and possibly non-Sanskrit and/or non-Indic sources dating from as early as the second millennium BCE. On the other hand, Mak and Geslani have focused on what this text tells us about the formation of the later ritual and astrological traditions, especially those represented by Varāhamihira. Zysk's account of the later Sanskritization and Brahmanization of the human marks in the Purāṇas and Nibandhas—as mediated by Varāhamihira—also follows such a line of inquiry. In this way, this second perspective aims to study the processes of systematization and appropriation that led to a mature Jyotiḥśāstra, fully integrated into Indian society. Without denying a possible first-century date for some portions of the *Gārgīyajyotiṣa*, such views are also open to a broader range of dates for the composition and/or compilation of the text, based on the type of material in the compilation, up to the period just before Varāhamihira, perhaps the early Gupta period.

Related to this latter trend, Yano's dating of the *Gargasamhitā* (G4) to after the sixth or seventh century, based on its mathematical contents, raises an additional question: why did Jyotiḥśāstra texts continue to be attributed to "Garga" after Varāhamihira's time? What sort of authority did Garga represent in the subsequent tradition, especially as compared to Varāhamihira? Did this later Garga corpus represent a sort of counter-tradition to other texts that would later become canonical *jyotiṣa* works? In these ways, further research on the later parts of the Garga corpus may shed light on the formation of Jyotiḥśāstra.

At every point in the history of the broader Garga corpus, many questions remain. In lieu of any further conclusions, we reiterate: research on the textual corpus of Garga remains in its infancy. Only a tiny portion of the *Gārgīyajyotiṣa* (G1) has been studied, and any prospect for further research depends on the publication of a full critical edition of the text, not to mention the various other tracts associated with this important name in the history of Jyotiḥśāstra. Those who gathered in New York in February 2017 hope, between us, to advance the publication of substantial portions of the *Gārgīyajyotiṣa* in coming years. The full production of this corpus will no doubt require further scholarly cooperation.

7. APPENDIX A. A SUMMARY OF THE *GĀRGĪYAJYOTIṢA*

The following summary is based on the enumeration of titles given in the introductory second chapter “*Aṅga-samuddiśa*” and the compilations by Mitchiner (1986: 105–11) and Pingree (1981: 69–71).

<i>Aṅga</i>	<i>Title</i>	<i>Contents</i>	<i>Folios</i> (MS. D)	<i>Chapter</i> in BS
	(Introduction)		1a–4a	2
1	Karmaguṇā	“Qualities of action”. Astrological characters of nakṣatras, tithis, grahas and muhūrtas.	4b–13b	98, 99
2	Candramārga	“Course of the Moon”	13b–18a	4
3	Nakṣatrakendrabha	“Appearance of the circle of nakṣatras”	18a–19a	
4	Rāhucāra	“Course of Rāhu”	19a–25a	5
5	Brhaspaticāra	“Course of Jupiter”	25a–26b	8
6	Śukracāra	“Course of Venus”	26b–31a	9
7	Ketumālā	“Line of Ketu”	31a–37b	11
8	Śanaiścaracāra	“Course of Saturn”	37b–39a	10
9	Aṅgārakacāra	“Course of Mars”	39a–40b	6
10	Budhacāra	“Course of Mercury”	40b–41a	7
11	Ādityacāra	“Course of Sun”	41a–45b	3
12	Agastyacāra	“Course of Agatsya”	45b–46a	12
13	Antaracakra	“Circle of intermediate region”	46a–51a	87
14	Mṛgacakra	“Circle of deer”	51a–57b	91
15	Śvacakra	“Circle of dogs”	57b–61a	89
16	Vātacakra	“Circle of wind”	61a–66b	27
17	Vāstuvidyā	“Knowledge of houses”	66b–78b	53
18	Aṅgavidyā	“Knowledge of limbs”	78b–84a	51
19	Vāyasavidyā	“Knowledge of birds”	84a–88b	95
20	Svātiyoga	“Conjunction with Svāti”	88b–89b	25
21	Āṣāḍhayoga	“Conjunction with Āṣāḍha”	89b–90b	26
22	Rohiṇīyoga	“Conjunction with Rohini”	90b–100b	24
23	Janapadavyūha	“Arrangement of countries”	100b–107a	14
24	Salila	“Rainfall”	107a–110a	
25	Grahakośa	“Collection of planets”	125a–127b	16–20
26	Grahasamāgama	“Conjunction of planets”	127b–130a	
27	Grahāmrādaḥṣṇyam		130a–130b	
28	Grahayuddha	“Opposition of planets”	130b–131a	
29	Grahaśṛṅgāṭaka	“Configuration of planets”	131b–141b	

30	Grahapurāṇa	"Purāṇa of planets"	141b–143b	
31	Grahapāka	"Effects of the planets"	144a–145b	
32	Yātrā	"Military astrology"	146a–150b	
33	Agnivārṇa	"Nature of fire"	150b–153b	
34	Senāvyūha	"Array of battle"	153b–156a	
35	Mayūracitra	"Variegation of peacock"	156a–160b	47
36	Bhuvanapuṣkara	"Lotus(-model) of the earth"	160b–165a	
37	Balyupahāra	"Offering of oblations"	165a–168b	
38	Śāntikalpa	"Rules for propitiation"	168b–177a	
39	Rāṣṭrotpātalakṣaṇa	"Signs and portents of calamity"	177a–186a	46
40	Tulākośa	"Weighing on balance"	186b–187b	
41	Yugapurāṇa	"Purāṇa of the yugas"	188a–193b	
42	Sarvabhūtaruta	"Cries of all creatures". Omens of various birds and animals.	193b–200a	
43	Vastracheda	"Tears in clothes"	200b–202a	71
44	Bṛhaspatipurāṇa	"Purāṇa of Jupiter"	202a–205a	
45	Indradhvaja	"Indra's banner"	205a–208b	43
46	Ajalakṣaṇa	"Signs of rams"	208b–211a	65
47	Kūrmalakṣaṇa	"Signs of turtoises"	211a–211b	64
48	Strīlakṣaṇa	"Signs of women"	211b–223b	70
49	Gajalakṣaṇa	"Signs of elephants"	223b–225a	67
50	Golakṣaṇa	"Signs of cows"	225a–228b	61
51	Bhārgavasamsthāna	"Appearance of Venus"	228b–229b	
52	Garbhasamsthā	"Appearance of embryos"	229b–231b	21
53	Dagārgala	"Water-divining"	231b–234b	54
54	Nirghāta	"Natural destructions"	234b–235b	39
55	Bhūmikampa	"Earthquakes"	235b–236a	32
56	Pariveśa	"Halos"	236a–238b	34
57	Ulkalakṣaṇa	"Signs of meteors"	238b–240b	33
58	Pariveśacakra	"Circle of halos"	240b–242b	34
59	Ṛtusvabhāva	"Nature of seasons"	242b–248b	
60	Sandhyālakṣaṇa	"Signs of twilight"	248b–251a	30
61	Ulkalakṣaṇa	"Signs of meteors"	251a–252b	33
62	Nakṣatrapuruṣakośa	"Compendium on nakṣatra-man"	252b–255a	105

8. APPENDIX B: TRANSMISSION EXAMPLE

By way of example of the of transmission process, I provide a case study in the form of a simplified version of the textual notes to Garga 1.2, where only the principal manuscripts (BhR and DC) and Bhaṭṭotpala's version (U=printed edition and mss B1 and B2) are cited.⁷⁹

GARGA 1.2 (THE LIST OF FOURTEEN LIKE PAIRS) (ZYSK)

*pāḍau gulpau sphijau pārśve vṛṣabhau cakṣuṣī stanau/
kaṇauṣṭhau sakthinī jaṅghe hastau bāhv akṣakau tathā//*

pārśve] BhR *karṇā karṇau*; DC *pārśvau*; U *pārśve*.
kaṇauṣṭhau] BhR *kaṇaiṣṭo*; DC *karṇoṣṭau*; B2 *karṇoṣṭhau* B1 *kaṇṭhoṣṭhau*;
 U *skandhausṭhau*.
sakthinī] BhR *savitp(y?)anī*; D *sakṭhinī*; C *saṭhæchinī*; B1 *vakṣaṇau*; B2
vaṃkṣaṇai; U *vaṅkṣaṇe*.
akṣakau] BhR *kṣakam*; D *kṣam*; C *kṣakaus*; U *aṃsakau*.

DISCUSSION

In b, U's reading is based on DC, while BhR is an intrusion. In c, BhR has Prakrit/vernacular *kaṇa* for *karṇa*.⁸⁰ The Sanskrit form is found in one ms, B2, while the other manuscript, B1, has *kaṇṭha*- "neck" and U has *skandha*-, "the two shoulders." Here the least Sanskritic reading is witnessed in BhR, a more Sanskritic version in DC, and finally an almost Sanskrit form in B2 (i.e., *karṇoṣṭhau*). The other manuscript (B1) and the printed edition (U) represent emendations.

In the same pāda, for the adopted reading *sakthinī*, BhR is unreadable, but D has something approaching Sanskrit, while U (printed and both mss) provides a synonym.

Finally, in d, U (printed and both mss) again provides the synonym for the manuscript version which is *(a)kṣakau*, which from *akṣaḥ* means the two axes or pivot points, i.e., the two shoulders. It is a less obvious word form, or *lectio difficilior*, for the shoulder.

⁷⁹ For more examples, the reader should examine closely the textual notes to Garga's chapters 1 and 2 in Zysk 2016: 2: 481–518;

555–96.

⁸⁰ See CDIAL: #2830, pp. 143–4.

ABBREVIATIONS

- CDIAL R. L. Turner (1966–1985). *A Comparative Dictionary of the Indo-Aryan Languages*. London, New York, Toronto: Oxford University Press. ISBN: 0 19 713550 1. URL: <http://dsal.uchicago.edu/dictionaries/soas/>. With *Indexes* compiled by Dorothy Rivers Turner (OUP, London, 1969), *Phonetic Analysis* by R. L. and D. R. Turner (OUP, London, 1971), and *Addenda and Corrigenda* edited by J. C. Wright (School of Oriental and African Studies, London, 1985).
- CESS David Pingree (1970–1994). *Census of the Exact Sciences in Sanskrit*. 5 vols. *Memoirs of the American Philosophical Society* 81, 86, 111, 146, 213. Philadelphia: American Philosophical Society.

REFERENCES

- Berggren, J. L. and Bernard R. Goldstein (1987). *From Ancient Omens to Statistical Mechanics: Essays on the Exact Sciences Presented to Asger Aaboe*. University Library. ISBN: 978-87-7709-002-8.
- Bisschop, Peter and Arlo Griffiths (2003). “The Pāśupata Observance (*Atharva-vedapariśiṣṭa* 40)”. In: *Indo-Iranian Journal* 46.4, pp. 315–48. DOI: 10.1023/b:indo.0000009508.18900.ef.
- Bolling, George Melville (1910). “A Contribution to the History of Religion in India”. In: *Catholic University Bulletin* 16, pp. 113–26. URL: <https://archive.org/details/CatholicUnivBulletinV16> (visited on 10/18/2017).
- Bolling, George Melville and Julius von Negelein, eds. (1909). *The Parisistas of the Atharvaveda*. Leipzig: O. Harrassowitz.
- Burgess, Ebenezer (1858). “Translation of the Surya-Siddhanta, A Text-Book of Hindu Astronomy; With Notes, and an Appendix”. In: *Journal of the American Oriental Society* 6, p. 141. DOI: 10.2307/592174.
- Chatterjee, Bina, ed. (1970). *Khaṇḍakhādyaḥ (an Astronomical Treatise) of Brahmagupta: With the Commentary of Bhāṭṭotpala by Brahmagupta*. Vol. 1. Delhi: Motilal Banarsidass.
- Dikṣita, Śaṅkara Bālakṛṣṇa (1896). *Bhāratīya Jyotiṣaśāstra* [= *Indian Astronomy*]. Trans. by R. V. Vaidya. Pune: Aryabhusana Press. English translation from the Marathi published in two volumes, Calcutta, 1969 and 1981.
- Eino, Shingo (2005). “The Formation of Hindu Ritual”. In: *From Material to Deity: Indian Rituals of Consecration*. Ed. by Shingo Eino and Jun Takashima. New Delhi: Manohar, pp. 7–49. ISBN: 978-81-7304-627-8.
- Falk, Harry (2000). “Measuring Time in Mesopotamia and Ancient India”. In: *Zeitschrift der Deutschen Morgenländischen Gesellschaft* 150, pp. 107–32.
- Geslani, Marko (forthcoming). *Rites of the God-King*. New York: Oxford University Press. Forthcoming.

- Geslani, Marko (2016). "Astrological Vedism: Varāhamihira in Light of the Later Rituals of the Atharvaveda". In: *Journal of the American Oriental Society* 136.2, pp. 305–323. ISSN: 0003-0279. DOI: 10.7817/jameroriesoci.136.2.305.
- Hoernle, A. F. Rudolf (Feb. 1888). "The Bakhshali Manuscript". In: *The Indian Antiquary* 17, pp. 33–48. URL: <https://archive.org/stream/in.ernet.dli.2015.530439/2015.530439.indian-antiquary#page/n43/mode/1up> (visited on 09/18/2017).
- Jha, Ramachandra, ed. (1986). *Yogayātrā*. Kāmeśvara Siṃha Granthamālā 23. Darabhanga.
- Jones, William (1790). "On the Antiquity of the Indian Zodiack". In: *Asiatick Researches* 2, pp. 289–306. DOI: 10.1017/cbo9781139506939.004. URL: <https://archive.org/details/in.ernet.dli.2015.91690> (visited on 10/22/2017).
- Kane, Pandurang Vaman (1949). "Varāhamihira and Utpala: Their Works and Predecessors". In: *Journal of the Bombay Branch of the Royal Asiatic Society* 24/25, pp. 1–32.
- Kern, Henrik, ed. (1865). *The Bṛhat Saṃhitā of Varāha-Mihira*. Calcutta: Baptist Mission Press.
- Kirfel, Willibald (1920). *Die Kosmographie der Inder*. Leipzig: K. Schroeder.
- Kumagai, Koji (2007). "The Gargasamhita, Chapter 39". In: *Journal of Indian and Buddhist Studies (Indogaku Bukkyogaku Kenkyu)* 55.2, pp. 795–789, 1262. DOI: 10.4259/ibk.55.795.
- (2011). "pāpa- on Divination Literature". In: *Journal of Indian and Buddhist Studies (Indogaku Bukkyogaku Kenkyu)* 59.3, pp. 1097–1102. DOI: 10.4259/ibk.59.3.1097.
- (2015). "The Construction of the Gargasamhita Chapter 39". In: *Journal of Indian and Buddhist Studies (Indogaku Bukkyogaku Kenkyu)* 63.3, pp. 1191–1196. DOI: 10.4259/ibk.63.3.1191.
- Laṃsāla, Devīprasāda, ed. (1969). *Aśvamedhīyayātrā*. Kāṣṭhamāṇḍapa: Rāṣṭrīyābhilekhālaya.
- Mak, Bill M. (2013a). "The Date and Nature of Sphujidhvaja's Yavanajāataka Reconsidered in the Light of Some Newly Discovered Materials". In: *History of Science in South Asia* 1, pp. 1–20. ISSN: 2369-775X. DOI: 10.18732/H2RP4T. (Visited on 09/21/2017).
- (2013b). "The Last Chapter of Sphujidhvaja's Yavanajāataka Critically Edited with Notes". In: *SCIAMVS: Sources and Commentaries in Exact Sciences* 14, pp. 59–148.
- (2014). "The 'Oldest Indo-Greek Text in Sanskrit' Revisited". In: *Journal of Indian and Buddhist Studies (Indogaku Bukkyogaku Kenkyu)* 62.3, pp. 1101–1105. DOI: 10.4259/ibk.62.3.1101.

- (2015). “The Transmission of Buddhist Astral Science from India to East Asia: The Central Asian Connection”. In: *Historia Scientiarum* 24.2, pp. 59–75. ISSN: 0285-4821.
- (2016). “Matching Stellar Ideas to the Stars: Remarks on the Translation of Indian jyotiṣa in the Chinese Buddhist Canon”. In: *Cross-cultural Transmission of Buddhist Texts: Theories and Practice of Translation*. Ed. by Dorji Wangchuk. Hamburg: Department of Indian and Tibetan Studies, pp. 139–158. ISBN: 978-3-945151-04-4.
- (2017). “Tithikarmagaṇa in Gārgyayajyotiṣa. Tithi Worship According to a Number of Early Sources”. In: *Journal of Indian and Buddhist Studies* 66. In press.
- (2018). “Bhaṭṭotpala and Scientific Learning in Tenth-Century Kashmir”. In: *Journal of Indological Studies* 29. In press.
- Mitchiner, John E. (1986). *The Yuga Purāṇa: Critically Edited, with an English Translation and a Detailed Introduction*. 1st ed. Bibliotheca Indica 312. Calcutta: Asiatic Society.
- (2002). *The Yuga Purāṇa: Critically Edited, with an English Translation and a Detailed Introduction*. 2nd ed. Bibliotheca Indica 312. Kolkata: Asiatic Society.
- Mukhopadhyaya, Sujitkumar (1954). *The Śārdūlakarṇāvadāna*. Santiniketan: Visvabharati.
- Negelein, Julius von (1928). “Die ältesten Meister der indischen Astrologie und die Grundidee ihrer Lehrbücher”. In: *Zeitschriften Der Deutschen Morgenländischen Gesellschaft* 82, pp. 1–22.
- Neugebauer, Otto (1957). *The Exact Sciences in Antiquity*. 2nd. New York: Dover. ISBN: 978-1-56619-269-9.
- (1975). *A History of Ancient Mathematical Astronomy*. Berlin/New York: Springer. ISBN: 978-3-540-06995-9.
- Pingree, David (June 1963). “Astronomy and Astrology in India and Iran”. In: *Isis* 54.2, pp. 229–46. ISSN: 0021-1753. DOI: 10.1086/349703.
- (1970–1994). *Census of the Exact Sciences in Sanskrit*. 5 vols. Memoirs of the American Philosophical Society 81, 86, 111, 146, 213. Philadelphia: American Philosophical Society.
- (1973). “The Mesopotamian Origin of Early Indian Mathematical Astronomy”. In: *Journal for the History of Astronomy* 4.1, pp. 1–12. ISSN: 0021-8286. DOI: 10.1177/002182867300400102.
- (1978). “History of Mathematical Astronomy in India”. In: *Dictionary of Scientific Biography. Supplement One*. Ed. by Charles Coulston Gillespie. Vol. 15. New York: Charles Scribner’s Sons, pp. 533–633. ISBN: 9780684169705.
- (1981). *Jyotiṣśāstra: Astral and Mathematical Literature*. History of Indian Literature. Wiesbaden: Harrassowitz. ISBN: 978-3-447-02165-4.

- Pingree, David (1987a). "Babylonian Planetary Theory in Sanskrit Omen Texts". In: *From Ancient Omens to Statistical Mechanics: Essays on the Exact Sciences Presented to Asger Aaboe*. Ed. by Bernard R Goldstein and J. L. Berggren. Copenhagen: University Library, pp. 91–99. ISBN: 978-87-7709-002-8.
- (1987b). "Venus Omens in India and Babylon". In: *Language, Literature, and History: Philological and Historical Studies Presented to Erica Reiner*. New Haven: American Oriental Society, pp. 293–315. ISBN: 978-0-940490-67-3.
- (1989). "MUL.APIN and Vedic Astronomy". In: *Dumu-e2-dub-ba-a: Studies in Honor of Åke W. Sjöberg*. Ed. by Hermann Behrens, Darlene Loding, and Martha Tobi Roth. Philadelphia: University of Pennsylvania Museum, pp. 439–445. ISBN: 978-0-934718-98-1.
- Plofker, Kim, Agathe Keller, Takao Hayashi, Clemency Montelle, and Dominik Wujastyk (2017). "The Bakhshālī Manuscript: A Response to the Bodleian Library's Radiocarbon Dating". In: *History of Science in South Asia* 5.1, pp. 134–50. ISSN: 2369-775X. DOI: [10.18732/H2XT07](https://doi.org/10.18732/H2XT07).
- Plofker, Kim and Toke Knudsen (2011). "Calendars in India". In: *Calendars and Years. II*. Ed. by John M. Steele. Oxford and Oakville, CT: Oxbow Books, pp. 53–68. ISBN: 978-1-84217-987-1.
- Rochberg-Halton, Francesca (1988). "Elements of the Babylonian Contribution to Hellenistic Astrology". In: *Journal of the American Oriental Society* 108.1, pp. 51–62. ISSN: 0003-0279. DOI: [10.2307/603245](https://doi.org/10.2307/603245).
- Rochberg, Francesca (2010). "Babylonian Astral Science in the Hellenistic World". In: *CAS LMU eSeries* 4, pp. 1–11. URL: http://www.cas.uni-muenchen.de/publikationen/e_series/cas_eseries_nr4.pdf (visited on 10/18/2017).
- Shukla, K. S., ed. (1960). *Mahābhāskarīya*. Trans. by K.S. Shukla. Lucknow University.
- Sugita, Mizue (1992). "Br̥hatsaṃhitā-ni okeru bhaṭṭotpala chūshaku [Br̥hatsaṃhitā Bhaṭṭotpala]". M.A. Japan: Kyoto Sangyo.
- Trautmann, Thomas R. (1997). *Aryans and British India*. Berkeley: University of California Press. ISBN: 978-0-520-91792-7.
- Tripāthī, A.V., ed. (1968). *Br̥hatsaṃhitā, with the Commentary of Bhaṭṭotpala*. Sarasvatī Bhavan Granthamālā 97. Varanasi: Varanaseya Sanskrit Vishvavidyalaya.
- Turner, R. L. (1966–1985). *A Comparative Dictionary of the Indo-Aryan Languages*. London, New York, Toronto: Oxford University Press. ISBN: 0 19 713550 1. URL: <http://dsal.uchicago.edu/dictionaries/soas/>. With *Indexes* compiled by Dorothy Rivers Turner (OUP, London, 1969), *Phonetic Analysis* by R. L. and D. R. Turner (OUP, London, 1971), and *Addenda and Corrigenda* edited by J. C. Wright (School of Oriental and African Studies, London, 1985).
- Weber, Albrecht (1852). *Indische Literaturgeschichte*. Berlin: F. Dümmler. URL: <https://archive.org/details/akademischevorle00owebe> (visited on 10/18/2017).

- Yano, Michio (forthcoming). “Nakṣatra System of the Atharvaveda-Pariśiṣṭa”. In: *Journal of Indological Studies*. Forthcoming.
- (1986). *Mikkyō senseijutsu* 密教占星術. Tokyo: Tokyo Bijutsu.
- (2004). “Planet Worship in Ancient India”. In: *Studies in the History of the Exact Sciences in Honour of David Pingree*. Ed. by Charles Burnett, Jan P. Hogendijk, Kim Plofker, Michio Yano, and Muzaffar Iqbal. Leiden: Brill, pp. 331–48. ISBN: 978-90-04-13202-3.
- Zysk, Kenneth G. (2016). *The Indian System of Human Marks*. Sir Henry Wellcome Asian Series 15. Leiden: Brill. ISBN: 978-90-04-29972-6.

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