

Bhaṭṭotpala and Scientific Learning in Tenth-Century Kashmir*

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1. Introduction

The tenth-century Indian astronomer Bhaṭṭotpala or Utpala is known to the modern Sanskritists for his immensely useful commentaries on a number of works by the sixth-century polymath Varāhamihira.¹ His commentaries on the latter's *Bṛhatsaṃhitā* (BS) and *Bṛhajjātaka* (BJ) are so helpful that when Hendrik Kern (1833-1917) edited and studied the texts from the manuscripts at Albrecht Weber's recommendation some time prior to 1861, he extracted a long list of technical terms from these commentaries, which was then included in Böhtlingk and Roth's *Petersburg Sanskrit-Wörterbuch* (seven volumes, 1855-1875).² The list was in turn incorporated into the Monier-Williams Sanskrit-English dictionary (first edition 1872, second edition 1899),³ which became a standard reference for today's Sanskritists.⁴ Our reading of BS and BJ, and the interpretation of a large body of otherwise obscure *jyotiṣa* terminology rely largely on Utpala's explanations. But who was Utpala? What was the lineage of his learning and his role in the larger *jyotiṣa* tradition of India? How was old knowledge renewed and new knowledge generated in the hands of the master commentator? These questions have not been adequately addressed.⁵ In this paper, in relation to the question of Utpala's learning, I will first examine the general life and culture of learning in Kashmir toward the end of the first millennium, drawing from al-Bīrūnī's testimonies. Secondly, I will

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¹ Kern 1865: 61-62.

² Also in the later and smaller version *Sanskrit-Wörterbuch in Kürzerer Fassung* by Böhtlingk (seven volumes, completed 1889), called usually the "Small Petersburg Dictionary" in contrast to the earlier "Large Petersburg Dictionary" (Zgusta 1988: 148-152).

³ Kern 1865: 64; Uhlenbeck 1917: 27; Yano and Sugita 1995: II.191.

⁴ That is, despite Böhtlingk accusing Monier-Williams of plagiarism. There are indeed cases where errors of the former, including those connected to BS, were reproduced in the latter. Monier-Williams in some cases corrected the errors or incorporated new information in the second edition, while in some cases retained the errors or even introduced new ones of his own (Zgusta 1988: 152-161, esp. 155).

⁵ For a preliminary study, see Shastri 1991: 201-212.

take a close examination of two of Utpala's works, his commentaries on BS and BJ, namely, the *Samhitāvivṛti* and the *Jagaccandrikā*, which may best characterize the scope and diversity of his learning. In examining these two topics, I hope to shed some light on the state of learning in tenth-century Kashmir where a versatile scholar such as Utpala was nurtured, revealing at the same time some broad trends of the Brahmanic culture of this period.

2. Utpala the Kashmiri astronomer

Despite the volume of works attributed to Utpala, we do not have a precise biographical account of this important author. From the colophons of the three commentaries, *Samhitāvivṛti*, *Jagaccandrikā*, and *Cintāmaṇi* (on the *Khaṇḍakhādya* by Brahmagupta), the date of the composition for these works is believed to be around 966 or 969 CE, thus establishing Utpala to be a tenth-century astronomer.⁶ As for his place of origin, Utpala gives no identification in any of his works. From the extant sources, it was al-Bīrūnī (973-1048), who in his *India* (c. 1030) first identified Utpala as a native of Kashmir.⁷ It should be noted that the works al-Bīrūnī attributed to Utpala do not tally exactly with the extant works. Nonetheless, Utpala's identity can be ascertained as the author of the commentary on BS.⁸ Al-Bīrūnī refers to him no less than nine times and adopted his version of Indian metrology.⁹ It thus appears that half a century after Utpala composed his works, he had become an authoritative figure in the astral science among the learned Brahmins in Kashmir. Al-Bīrūnī's work, as a testimony to Utpala's works, contains also a number of references to Kashmir. As such it would not be inappropriate to give first an overview of the cultural milieu of the late tenth-century Kashmir based on al-Bīrūnī's account. For the purpose of this paper, let us turn to what we know about Kashmir in terms of its culture of learning, in particular, astronomical studies at the time of Utpala's compositions. We know that al-Bīrūnī had probably never set foot in Kashmir, which had closed its borders after Maḥmūd's invasion in 1015 (second invasion in 1023). Travel was not restricted in the region under Ghaznavid control, however, for the local Hindus, to the extent that al-Bīrūnī was provided abundant information by his Kashmiri

⁶ CESS A4: 270-283; A5: 246-249.

⁷ Sachau 1910: I.157, 298, 334, 367. On the background of *India* (*Kitāb taḥqīq mā li'l-Hind*), and its purport to "set out in clear and dispassionate detail a true picture of Indian civilization based on authentic primary sources" after the death his patron Maḥmūd of Ghazna, see Yano 2013: 53; Kozah 2016: 23, 27 ff.

⁸ Sachau 1910: I.298.

⁹ Appendix D. Note however the discrepancy between the reported system (IV) and the one found in Utpala's work (I). See also fn. 31.

informants on various aspects of Kashmir and was even able to acquire a Kashmiri almanac of the previous year (Śaka 951 = 1029).¹⁰ Al-Bīrūnī's writing on Kashmir covers a wide range of topics including geographical notes, political situations, customs, festivals and weather.

Although Kashmir had a turbulent history and had transitioned from the Utpala Dynasty to the Lohara rule in 1003, the region remained largely Hindu during the tenth century, with a prominent Brahmin community known for its conservative traits, and whose influence lasted up to the Sultanate period in the fifteenth century.¹¹ In al-Bīrūnī's view, Kashmir and Varanasi were the major centers of Hindu learning at the time as other parts of North India were severely disrupted by the Islamic conquest.¹² Kashmir, in particular its capital Adhiṣṭhāna, saw an influx of learned Brahmins who took refuge there, from the neighboring regions such as Peshwar, whose ruler Ānandapāla fled also to Kashmir. It is likely that al-Bīrūnī's informants found themselves in similar situations due to the unrest in the region.

The image of Kashmir as a center of Brahmanic learning was corroborated both by Sanskrit accounts such as the *Nīlamata* and Kalhaṇa's *Rājatarāṅgiṇī* (RT),¹³ beside al-Bīrūnī's *India*. The Brahmins of Kashmir, as in elsewhere in medieval India, were engaged in traditional duties such as study, teaching, performing sacrifices for themselves, officiating for others, making and accepting gifts.¹⁴ There are accounts of Kashmiri Brahmins, as expected, engaged in works related to astronomy and astrology.¹⁵ According to al-Bīrūnī, some unique aspects of Kashmiri learning were also noted. In Kashmir, the *Siddhamātrkā* script was used, in contrast to the *nāgarī* and other scripts employed in other parts of India.¹⁶ They also used a special kind of numeral signs.¹⁷ A number of curious anecdotes related to Kashmiri pandits are worthy

¹⁰ Sachau 1910, I.391; Kozah 2016: 23.

¹¹ According to Bühler, the Kashmiri Brahmins (of nineteenth century) formed one unified community whose members "interdined" (*annavyavahāra*) and taught each other (*vidyāvvyavahāra*, *vidyāsambandha*), but intermarriage prohibitions were observed among certain subdivisions, for example, the "astrologer class" (*Jotish*) did not intermarry with the "priest class" (*Guru* or *Bāchabat*). It is not certain how strongly these subdivisions were enforced in the tenth century, but given the scope of Utpala's learning, he must have been regarded as a respected member of the "Jotish Pundits," who were tasked to prepare calendars and make annual prophecies (Witzel 1994: 237-294).

¹² *Ibid.*, xlv, 22-23.

¹³ *Ibid.*, 262-264, 272-273; Witzel 2016: 628-631.

¹⁴ That is, according to the *Kuṭṭanīmata* (c. 779-813 CE, cited in Witzel 2016: 618), corroborated by al-Bīrūnī (Sachau 1910: II.133).

¹⁵ RT 8.76, 5.28-29; Witzel 2016: 635.

¹⁶ Sachau 1910: II.173.

¹⁷ *Ibid.*, II.174.

of note, among them a certain Vasukra, who committed the Vedas to writing out of the fear of their disappearance in the age of corruption.¹⁸ There is also a description of an author who bribed the local pandits to study his latest grammatical treatise with a handsome reward of 200,000 dirham.¹⁹ At any rate, the academic culture described appears to be vibrant, with a blend of traditional learning and regional traits. As we shall see, such traits are shown also in Utpala's works where characteristic words with Kashmiri influence can be found.²⁰

In terms of its calendar system, Kashmir appears to be unique among the Northern regions in that the year begins from the new moon of the month of *Caitra*, which al-Bīrūnī was keen to note as the system used by the Indian astronomers.²¹ Records indicate that up to the beginning of the eleventh century, the *amānta* system (beginning and ending with the new moon) was used in Kashmir, as attested also in works such as *Nīlamata* composed some time from the early seventh to the middle of the ninth century,²² and Utpala's *Jagaccandrikā* (§2.2).²³ The seasons in Kashmir are naturally different from the rest of India because of the higher latitude. There is no rainy season (*varṣā*); instead snow falls for two and a half months from the month of *Māgha* until the middle of *Caitra*. Besides the ordinary Hindu festive days, two additional festivals were noted in Kashmir, namely the festival of "Agdūs" celebrating the victory of Muttai over the Turks on the second day of *Caitra*, and a festival with floating pieces of wood on the Vitastā (Jhelum river) celebrated on the full moon day of *Vaiśākha*, or according to another source, on the 26th/27th day of *Bhādrapada*.²⁴

Although the accuracy of al-Bīrūnī's account as with his Sanskrit ability has been questioned,²⁵ he had access to a large number of Sanskrit

¹⁸ Ibid., II.126-7.

¹⁹ Ibid., II.136.

²⁰ Examples (**bold** for words with Kashmiri influence) include *gañja* < *kośabhavana*, *ḍoma* < *śvapaca*, *manīvaka* < *mokṣaka* (a kind of tree), *ekkalakka* < *jānukapicchā*, *aṅga* < *śaṅku*, *yavaśīras* < *yavagrīva*, *maṅḍala* < *mṛdaṅga* (a musical instrument), *kanaka* < *vitāna*, *śoḍanikā* < *kṣveḍa* (cough), *lāṭā* < *bharadvāja* (a kind of bird), *duṣṭa* < *cokṣa*, *dāṃdāni* < *bhṛṅgāra* (golden pot), *sārthin* < *sahāya* (Bhat 1981: xliii-xliv; Shastri 1991: 204; consolidated in Sugita 1992: 3).

²¹ Sachau 1910: I.348-9, II.8.

²² Ikari 1994: i; Yano 1994: 223-236, esp. 229-233 (*amānta* vs. *pūrṇimānta*). Generally speaking, in modern as well as in ancient India, the calendar of the north is of the *pūrṇimānta* type, while that of the south the *amānta*. What remains unclear is how and when the *pūrṇimānta* system was established in Kashmir by the time of Kalhaṇa a century later.

²³ Cmty. on BJ 8.10, also BJ 26.4.

²⁴ Ibid., II.181.

²⁵ Pingree 1975. A close examination of al-Bīrūnī's "translations" reveals that al-Bīrūnī was

astronomical texts and many of them appear to have come from Kashmir.²⁶ The only Indian almanac he acquired was one from Kashmir and no almanac from other parts of India was mentioned.²⁷ He noted the precessional discrepancies of the position of the *saptarṣayaḥ* (the seven stars of Ursa Major) when he compared the values in the Kashmiri almanac with those in the *Gargasamhitā* (known also as *Gārgyājyotiṣa*) and Varāhamihira's BS.²⁸ On the subject of precession of the equinoxes, he suggested that Utpala must have adopted the values given by one Muñjāla (or Puñjala, fl. 932).²⁹ His knowledge of Utpala's astronomical views was gleaned from a work titled *S.rū.dh.w.*, which is no longer extant.³⁰ The metrology described in this work by Utpala was recommended by al-Bīrūnī as it was adopted by another learned Indian astronomer.³¹

In total, al-Bīrūnī mentioned six works by Utpala:³²

- 1) *Rā.h.t.rakarāṇa*. [Sachau: *Rāhunrākaraṇa*; Pingree: *Ārdharātrikakarāṇa*], an astronomical handbook;
- 2) *Karaṇaghāta*. Another astronomical handbook;
- 3) *Ṭīkā* on *Bṛhanmānasa* by Muñjāla (fl. 932);
- 4) *Praśnacūḍāmaṇi* (= *Āryāsaptati*). A short work on interrogative

unlikely to be able to decipher technical *jyotiṣa* terms himself (Pingree 1975: 78), and his Sanskrit could not be "profound" (Pingree 1983: 353, fn. 1).

²⁶ According to Kozah, al-Bīrūnī refers to at least ten Hindu works in *India*. Among the astronomical works, these include *Brāhmasphūtasiddhānta* of Brahmagupta, BS, *Laghujātaka*, *Pañcasiddhāntikā* (incl. *Paulisasiddhānta* of Paulisa and *Romakasiddhānta* of Śrīsenā), *Khaṇḍakhādya* of Brahmagupta. Other non-astronomical works include *Yogasūtra* of Patañjali and the *Gīta* (Kozah 2016: 37, fn. 24). In the *India* al-Bīrūnī appears to suggest that he had translated or begun to translate into Arabic a number of Sanskrit texts including *Laghujātaka* and BS, presumably with Utpala's commentaries (Sachau 1910: I.xxxvii, see references to *Fihrist*; Shastri 1991: 166; Yano 2013: 54). This is, however, by no means certain.

²⁷ Yamamoto and Yano 2012: 342.

²⁸ Sachau 1910: I.391-3; Yano 1972: 967.

²⁹ Sachau 1910: I.366-8; CESS A4: 283, 435 ff. On the *Gargasamhitā*, see Geslani, Mak, et al. 2017: 151-155; Mak 2019.

³⁰ The original Sanskrit title is unknown but was tentatively suggested by Sachau and Pingree to be *Śrūdhava* and *Sūtradhāra* respectively. This work was mentioned twice by al-Bīrūnī in chapters 34 and 39, both in describing time units (see next note). According to al-Bīrūnī, there is another *jyotiṣa* work of the same title by Mahādeva which gives the calculation of era, dominant thirds of the day and the inauspicious "burning days" throughout the year (ibid., I.6, 120, 192, 344). Sachau believes the two works to be different though sharing some common topics (ibid., I.389).

³¹ The astronomer was identified somewhat cryptically as ŚMY. Appendix D (IV).

³² Described in Ch.14, 29, 34, 39. Summarized in CESS A4: 283. Also, Sachau 1910: II.306. The Sanskrit reconstruction of lost titles by Sachau and Pingree are conjectural.

- astrology in seventy verses;
 5) *Samhitāvivṛti*. Commentary on BS;
 6) *S.rū.dh.w*

Out of the six works explicitly mentioned by al-Bīrūnī, only two are extant, namely, 4) *Praśnacūdāmaṇi* (= *Āryāsaptati*), and 5) *Samhitāvivṛti*.

3. Utpala's learning

Utpala's learning can be best exemplified by his works which consist of both commentaries to the works of others as he was known for, as well as some independent, but lesser known works of his own. To date, besides those mentioned by al-Bīrūnī, no less than ten of his works are extant:³³

A. Commentary on Varāhamihira's works

1. *Samhitāvivṛti*. Commentary on BS. Dated 967.2.28.
2. *Jagaccandrikā*. Commentary on BJ. Dated 966 (?).³⁴
3. *Śiṣyahitā*. Commentary on *Laghujātaka*. Dated 966.10.21.
4. *Yajñeśvamedhikā*.³⁵ Commentary on *Bṛhadātrā*.
5. Commentary on *Yogayātrā*.
6. *Cintāmaṇi*. Commentary on *Vivāhapaṭala*. Dated 1017 (?).³⁶

B. Commentary on other works

7. Commentary on *Ṣaṭpañcāśikā* by Pṛthuyāsa (fl. 575).³⁷
8. *Cintāmaṇi*. Commentary on *Praśnavidyā* by Bādarāyaṇa.
9. *Cintāmaṇi*. Commentary on *Khaṇḍakhādyaka* by Brahmagupta.³⁸
Dated 969.3.25.

C. Independent works

10. *Praśnajñāna* = *Āryāsaptati* = *Bhuvanadīpaka* = *Jñānamāla*.

For the purposes of this paper, my focus will be on the first two works, which are arguably among the most erudite works of Utpala.

³³ CESS A4: 270 ff.

³⁴ The dating is problematic according to Pingree (CESS A4: 270).

³⁵ Not noted in CESS; Sugita 1992: 6.

³⁶ The date is unlikely since this is nearly fifty years after the *Samhitāvivṛti* was written (ibid., 7).

³⁷ Son of Varāhamihira (CESS A4: 212).

³⁸ Recently, Lü Peng of Kyoto University has completed his Ph.D. dissertation, "The *Khaṇḍakhādyaka* with the Commentary of Utpala: Study, Translation, Mathematical Notes and Critical Text."

3.1 *Samhitāvivṛti* - Commentary on BS

BS is a versified compendium of Indian astral science of the miscellaneous variety,³⁹ with diverse subjects ranging from astrology and divination, to iconography, gemology, geography to perfumery.⁴⁰ The purpose of the commentary was stated in the opening verses of the work:

*brahmājaśaṅkararavīndukujajñajīvaśukrārkaputragāṇanāthagurūn
praṇamya | yaḥ saṃgraho 'rkavaralābhavivṛddhabuddher āvantikasya
tam ahaṃ vivṛṇomi kṛtsnam ||1||
yac chāstram savitā cakāra vipulaiḥ skandhais tribhir jyautiṣam
tasyocchittibhayāt punaḥ kaliyuge saṃsṛtya yo bhūtaḥ |
bhūyah svalpataram varāhamihiravyājena sarvaṃ vyadhād
itthaṃ yaṃ pravadanti mokṣakuśalās tasmai namo bhāsvate ||2||
varāhamihirodadhau subahubhedatoyākule
graharkṣagaṇayādasi pracurayogaratnojjvale |
bhramanti parito yato laghudhiyo 'rthalubdhās tataḥ
karomi vivṛtiplavaṃ nijadhiyāham atrotpalah ||3|| (BS 1.1-3)*

[Translation] Having made obeisance to Brahma, Viṣṇu, Śiva, Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, Ganesh and teachers, I will annotate the entire collection of works by the one from Āvanti, whose fully developed intelligence was obtained through the boon of the Sun. Savitṛ created the astral teachings with three comprehensive branches. Fearing that its transmission may be terminated, he (the Sun) reincarnates in the Kali Yuga into the world again. In the guise of Varāhamihira, he furnished the entire work into much smaller ones in this manner. Homage to the shining one, the one whom the “*mokṣakuśala*”-s⁴¹ proclaim.⁴²

³⁹ According to Varāhamihira (BS 1.19), the *saṃhitā* (miscellany, lit. compilation) is one of the three genres of Indian astronomical texts. The scheme was based most likely on an earlier one described in the *Gārgīyajyotiṣa*. The other two are mathematical astronomy (*gaṇita* or *tantra*) and horoscopy (*horā* or *jātaka*). On the different interpretations of these categories, see Mak 2015: 4, fn. 9.

⁴⁰ The text was first edited and published by Kern starting from 1865 (107 chapters) and by Dvivedin in 1897 together with Utpala's commentary (CESS A5: 570).

⁴¹ Literally, “the one skilled in liberation.” Sanderson suggested to me that this could be a *saura* Iranian term, referring to the Sun-worshippers. The Indo-Scythians called the Sun god *mokṣeśa*, *mokṣa* and *bhojaka*. The last term is connected to the Pāhlavī word *bōzēt* as in *Miθrbōzēt*, “delivered or released by Mithra.” Thus *mokṣakuśalās* may be analogous to terms such as *mokṣavedinaḥ* and *mokṣagāminah*, all connected ultimately to the Sun-worshipping Magas (Scheftelowitz 1933: 305-6). See fn.44.

⁴² Sanderson pointed out to me that *pra*√*vad* does not seem to work here and proposed an emendation of *praṇamanti* (“they venerate”).

Varāhamihira is the ocean filled with the greatly variegated water [from different sources], the sea-monster [made up] of a plethora of planets and asterisms, with the luster of the gems of [their] multitudinous combinations/conjunctions (*yoga*-). As the dim-witted ones, desirous of meaning, go woefully adrift, I, Utpala, with my own understanding thus created this raft of commentary for this [ocean of astral knowledge].⁴³

Utpala's description of Varāhamihira, a native of Āvanti not far from Ujjain, as the reincarnation of the Sun refers most likely to Varāhamihira's connection with the solar cult and his Maga ancestry which he described as *magadhadvija*.⁴⁴ Unlike Varāhamihira, Utpala did not seem to have any sectarian affiliation. His concern was to help the readers to navigate through the massive texts of Varāhamihira in a comprehensive and methodical manner, through glosses, variant readings, and a large amount of citations from different authors whose works are often no longer extant.

Among Utpala's 1170 citations of a total of over 2,300 verses, 964 citations or about 2,000 can be identified with known titles (63 in total).⁴⁵ Among these known works, the most cited work is *Parāśara*, followed by *Garga*, *Kāśyapa*, and *Samāsasamhitā* (Varāhamihira's own abridgement of BS).⁴⁶ Among the non-*vyotiṣa* works cited are grammatical treatises such as those of Pāṇini and Kātyāyana, and the medical work of Caraka. Of particular interest are the quotes from astronomical works such as the *Pañcasiddhāntikā* (PS) and the *Āryabhaṭṭya*. It may be noted that in this genre of *samhitā* text, detailed mathematical and astronomical explanations are not expected. Utpala at times nonetheless took the opportunity to enlighten his readers, sometimes with lengthy digression, suggesting the didactic intention of the author with possibly

⁴³ While the topos to compare a work to a raft traversing the ocean of knowledge or an expansive work of a predecessor is common (*Raghuvamśa* 1.2cd: *tīṅṅsur dustaram mohād uḍupenāsmi sāgaram*), the comparison of the celestial bodies to elements of the ocean and the sea monster is curious.

⁴⁴ The Sun connection can further be seen in his father's name Ādityadāsa (BJ 26.5) and the ending of his own name *mihira* associated with Mithra, the Iranian Sun-god, and the Indo-Iranian Magas (Shastri 1991: 9-15). The interpretations of *magadhadvija* among scholars vary and remain unresolved, taking *Magadha* either literally or synonymously with Maga, based on a passage from *Bhaviṣyapurāṇa* (Kern 1865: 1-2; Shastri 1969: 19-20, 1991: 8, 10, 26-27 fn.73; Pingree 1981: 32; Yano and Sugita 1995: 184). At any rate, Varāhamihira himself describes the Sun worshippers as *magas* (BS 59.19).

⁴⁵ Appendix A.

⁴⁶ On the *Samāsasamhitā*, or *Svalpasamhitā*, see Shastri 1991: 18-20, 62-64. Though the text is no longer extant, from Utpala's citations of the text, the work appears to be not only an abridgement, but an improvement of BS, including even some new materials.

a young audience in mind.

Utpala's heuristic approach is demonstrated by the way he presents different or sometimes even contradictory systems, arranged in a way that would justify his preferred rendering, presented to the readers often at the outset of each section. An example of such kind is his explanation of the time units (* indicates source unknown):⁴⁷

1. Recommendation of PS as the reference for the knowledge of the time units
2. Definition of *yuga* and year
 - a. Utpala's system
 - b. Quotation from *Brahmasiddhānta* (= *Brāhmasphuṭasiddhānta* [BSS] 1.7-8)⁴⁸
 - c. Quotation from **Paulīśasiddhānta*⁴⁹
3. Definition of *ayana* and seasons
 - a. Utpala's system
 - b. Quotation from "teacher" (= *Paulīśasiddhānta*, PS 3.25)
 - c. Quotation from **Brahmasiddhānta*

⁴⁷ Appendix C (text and translation).

⁴⁸ Two of the three citations Utpala attributes to the *Brahmasiddhānta* in this passage are identical to Brahmagupta's BSS (629 CE). Dvivedin in his edition of the *Samhitāvivṛti* claims the two titles to be identical (*brahmaguptakṛtabrāhmasphuṭasiddhānta ity arthaḥ*, BS 2(2), p.22-23, passim; see Sugita 1992: V9-10 for other instances). Elsewhere in the *Jagaccandrikā* Utpala refers to his citation of BSS to be *brahmaguptena* (BJ 1.19, p. 28). Pingree notes that Utpala cites Balabhadra's now lost commentary (eighth century) on the BSS (Pingree 1983). It is therefore clear that Utpala had access to BSS. The difficulty arises when he refers to the title *Brahmasiddhānta* as one of the five *siddhāntas* of PS in this section. The extant recension of the *Brahmasiddhānta* or *Paitāmahasiddhānta* in PS bears no relation to BSS. However, as Pingree pointed out, the former was used in the latter (Pingree 1969: 178). In fact, Brahmagupta named his work *Brāhmasphuṭasiddhānta* precisely because it was intended to be an improvement on the *Brahmasiddhānta* (*Brahmokaṭaṃ grahagaṇitaṃ mahatā kālena yat ślathībhūtam | abhidhīyate sphuṭaṃ tajiṣṇusutabrahmaguptena* || BSS 1.2). I am inclined therefore to believe that Brahmagupta cited materials from the old *Brahmasiddhānta* in his BSS and Utpala considers this *Brahmasiddhānta* to be one of the five treatises of the PS. Varāhamihira's PS contains only a portion or a different recension of the old *Brahmasiddhānta*. On Brahmagupta's time units, see Hayashi 2017: 39-40.

⁴⁹ The citation here cannot be traced in the extant edition of PS (see Sugita 1992: V-9 for other instances). However, at least a line cited by Utpala, attributed to the *ācārya*, i.e., Varāhamihira (3b), can be traced to the extant *Paulīśasiddhānta* in the PS (composed by Lāṭadeva according to Varāhamihira). Therefore, the *Paulīśasiddhānta* Utpala referred to must be a different recension from that of the extant PS. According to Pingree, these citations of the *Paulīśasiddhānta* not found in the extant PS belong to the "later *Paulīśasiddhānta*" (Pingree 1969: 173).

4. Definition of time unit
 - a. Utpala's system (I)
 - b. Quotation from *Parāśara. (II)
5. Definition of spatial unit (III)
 - a. Utpala's recommendation of spatial unit (*kṣetra*) correlated with time unit (*kāla*)
 - b. Quotation from *Brahmasiddhānta* (= BSS 1.5-6)
 - c. Quotation from **Paulīśasiddhānta*
 - d. Quotation from Āryabhaṭa (= *Āryabhaṭīya*, *Kālakriyāpādaḥ* 1-2)

Beside the natural temporal units such as day, month and year, some arbitrary units such as the *tithi* (defined as one thirtieth of a synodic month) and *muhūrta* (one thirtieth of a day) have remained stable. However, for a large part of temporal units of lower order, their definitions remain varied with each text, as al-Bīrūnī noted.⁵⁰ Earlier authors such as Varāhamihira simply presented the units as if there was only one system. Utpala must have noted the discrepancy, which he however did not problematize. Instead, he provided at the outset various schemes that displayed no contradiction, followed by citations that would justify his choices. In the case of time unit, after presenting a system of his own without stating explicitly so (I), he appealed to the authority of Parāśara (II), whose scheme is by no means common. The combination of units of lower order such as *nimeṣa*, *truṭi*, *lava*, *kṣaṇa*, *kāṣṭhā* is in fact attested in no other extant *jyotiṣa* texts, with the exception of possibly the *Gārgyājyotiṣa*.⁵¹ Such unique choice is possibly motivated by the fact that Utpala considered Parāśara and Garga to be the main sources of Varāhamihira's works, as well as possibly of the Indian astral tradition at large.⁵²

The higher units of Utpala's scheme [I, Table 1(a)] comes from the one adopted in later astronomical works such as *Brahmasiddhānta*, *Paulīśasiddhānta* and *Āryabhaṭīya* (III), which he cited at the end of the section. One may note the use of sexagesimal units in this scheme (1 *ghaṭikā/nāḍī* = 60 *viḡhaṭikā/vināḍikā*, 1 day = 60 *ghaṭikā/nāḍī*), corresponds to the Greco-

⁵⁰ For a survey of Indian time units, see Srinivasan 1979: 118-161 and Hayashi 2017.

⁵¹ It may also be noted that this particular combination of lower time units is rather rare, but resembles the ones given at the beginning of all the extant mss. of the *Gārgyājyotiṣa* (unedited) as the time units a *sāmvatsara* (astronomer) should know: *nimeṣakṣaṇakāṣṭhādītruṭilavamuhūrta-horātrapakṣamāsartavayanaviśuvid* (Mak 2019: 57). The only other text where the five lower units are included is the *Mahābhārata* though the conversion could be either different or not given (Hayashi 2017: 55).

⁵² In the *Samhitāvivṛti* the number of quotations from Parāśara, followed closely by Garga far outweighs the others (Appendix A); Utpala places Parāśara first among all the references he cited (Appendix C).

Babylonian minutes and seconds.⁵³ The reason for the choice is the parallelism between the spatial [1(a)] and temporal unit [1(b)] inherent in this system (*evaṃ kālasya vettā tathā kṣetrasya vettā*):⁵⁴

Table 1(a) Utpala's temporal units (scheme III)

	prā	Vi	gha	day	month	year
prāna	1					
vighaṭikā	6	1				
ghaṭikā	360	60	1			
day	21600	3600	60	1		
month	648000	108000	1800	30	1	
year	7776000	1296000	21600	360	12	1

Table 1(b) Utpala's spatial units (scheme III)

	Ta	vi	li	bhā	rā	bha
tatapara	1					
viliptā (second)	60	1				
liptā (minutes)	3600	60	1			
bhāga (degree)	216000	3600	60	1		
rāśi (sign)	6480000	108000	1800	30	1	
bhagaṇa (cel. globe)	77760000	1296000	21600	360	12	1

Upon a closer look of Utpala's system (I), however, one may note that although the conversion of “1 *vighaṭikā/vināḍi/vināḍikā* = 6 *prāna*” was given in scheme (III), it was never adopted explicitly in (I). Instead, Utpala interprets *prāna*, curiously, as “one breathing of in and out” (*śvāsanirgamapraveśau*). Should he have adopted the conversion in scheme (III), the relation between *prāna* and the lower units of Parāśara would collide, resulting in awkward fraction (shown in brackets). To avoid such inelegance, Utpala combines two systems of temporal units as if they do not interfere with each other. His approach thus

⁵³ For a comparison of Indian sexagesimal units, in particular, among Greco-Indian or Indo-Greek astral texts, see Mak 2013: 80-81.

⁵⁴ Except of course *prāna*. Note that the application of the Indian spatial sexagesimal units for astronomical measurement corresponds to its Greco-Babylonian counterpart, but not the temporal ones. In the Indian system, the sexagesimal principle is applied to a day as to a degree, with the underlying assumption that the Sun moves one degree (*amśa*) or 60 arc minutes (*liptāḥ* = λεπτά) per solar day in a 360-day year. Furthermore, as Pingree pointed out, the sexagesimal sub-units of a day (*ghaṭikā*, *vighaṭikā*, etc.) applies to a 24-hour day, not a solar day (Pingree 1969: 179).

appears to be one that attempts to make the best sense out of the materials available to him. His goal therefore is to provide the readers a solution that is rational and convenient, presented heuristically without undermining authorities such as Parāśara, and without the need to go into any lengthy justification. Such approach is markedly different from that of al-Bīrūnī, who noted the contradiction and remarked without hesitation, “The Hindus are foolishly painstaking in inventing the most minute particles of time, but their efforts have not resulted in a universally adopted and uniform system.”⁵⁵

3.2 *Jagaccandrikā* - Commentary on BJ

Unlike BS which is a large collection of related and unrelated topics, BJ is an attempt to present a coherent system of Greco-Indian genethliacal astrology (*horā* or *jātaka*) in twenty-eight chapters (409 verses in total). The text to this day remains an authoritative manual for the casting of horoscopes and is widely learned by traditional Indian scholars as part of their general curriculum. Although there appear to be some textual problems with the opening and closing parts of the original work of Varāhamihira,⁵⁶ Utpala composed both the *Jagaccandrikā* and the *Samhitāvivṛti* likely at the same time as an effort to comment on the major works of Varāhamihira in all three branches of *jyotiṣa*.⁵⁷

BJ contains copious references to earlier authors such as Garga, Parāśara, Maya, Yavana, Maṇṭha, Satya, Śaktipūrva, Viṣṇugupta, Devasvāmin and Jīvaśarman as sources for Greco-Indian horoscopy. Among them, Garga and Parāśara are as attested widely in the classical Sanskrit literature. On the other hand, the lesser known names appear to be of foreign origin despite their Sanskrit or Sanskritized forms.⁵⁸ Some of the names of these authors are likely

⁵⁵ Sachau 1910: I.334-336. Al-Bīrūnī presents also a system (IV) attributed to Utpala, which does not tally with the one given in the *Samhitāvivṛti* (I). We are not certain whether it was a mistake of al-Bīrūnī or his informants, or a problem on the side of Utpala’s text.

⁵⁶ The *maṅgala* verses of the *Jagaccandrikā* are identical to those of the *Samhitāvivṛti*. According to Pingree, the date in the colophon is problematic because it carries the same date (month, *pakṣa*, *tithi* and *vāra*) but two years earlier, which is a mathematical impossibility (CESS A4: 283). Pingree thus suggests that the first and second halves of the verse containing the date were copied from the *Samhitāvivṛti* and the *Cintāmaṇi* (commentary on the *Vivāhapaṭala*). The problem remains unsolved.

⁵⁷ As Utpala himself mentioned earlier: *yaḥ saṃgraho...tam ahaṃ vivṛṇomi kṛtsnam*. See also earlier in §1 on al-Bīrūnī’s descriptions of the two astronomical handbooks (*karaṇa*) by Utpala which are no longer extant.

⁵⁸ There is very little one can say about these authors unless more citations attributed to them are identified and analyzed. One should, however, take into account the possibility of false attribution or multiple authors with the same name. From Utpala, through his citations and commentary, we learn about the distinct teachings of Gargas and Vṛddhagarga, or “Garga the Elder” (Kane 1949: 1-32; Bhat 1981: xlv). The two authors were likely both

to be of Greek origin, although it is not certain in the case of Yavana (Ἰάφων or Ἴων),⁵⁹ Maṇittha (Greco-Egyptian Μανέθων?),⁶⁰ Maya ([Πτολε]μαῖος?),⁶¹ whether they refer to the original authors or the Sanskrit translators and transmitters.

In terms of their content, much of these references contain elements of ultimately Greco-Babylonian origin, though their provenance remains unclear as some of the key concepts such as *navāṃśaka* (division of a sign into nine parts) have no counterparts in Greco-Babylonian materials and appear to be an Indian innovation.⁶² Since there is no trace of genethliacal astrology in the extant Vedic corpus, such materials have a decidedly different flavor, and was by then supplanting rapidly the older Vedic astrology of the lunar variety.⁶³ This new body of astral lore was received with great enthusiasm by the early Indians as attested by the great number of Sanskrit writers who presented

named Garga originally and later authors named one Vṛddhagarga to disambiguate him from the other who must have been thought to be later (Mak 2019: 57).

⁵⁹ Tarn 1951: 129ff, 416-418; Narain 1957: 165-169; Karttunen 2015: 328-337.

⁶⁰ Pingree 1978: I.39. Lopilato however found no relation between the Ἀποτελεσματικά of Μανέθων and the Sanskrit citations attributed to Maṇittha (Lopilato 1998: 9). For criticism on Lopilato and Pingree's emendations to the Greek text based on "Konjekturen... größtenteils nicht notwendig oder gar unmetrisch," see De Stefani 2017: 42, fn. 167.

⁶¹ Weber 1853: 243. The identification was accepted by Lévi, but was described recently by Karttunen as "far-fetched," (Karttunen 2015: 374, fn. 259). Mīnarāja's *Vṛddhayavanajātaka* is likely an abridged version of Maya's work which is no longer extant (Mak 2017: 3, 10-11, fn. 45).

⁶² Pingree 1978: II.211. In Greco-Babylonian astral science, the sky was divided into twelve signs as celestial coordinates. The division of a sign into nine parts results in 108 parts in one revolution, which as far as I can tell, has no meaning in the Greco-Babylonian system. On the other hand, in traditional Vedic astral science the sky was divided into 27 or 28 *nakṣatras* with the 27-*nakṣatra* system generally favored by later astronomers including Varāhamihira. It should be of no coincidence that 108 is the smallest common multiple of 27 and 12. Hence, prediction utilizing the concept of *navāṃśaka* could be easily applied to a system common to the zodiac and the *nakṣatras*. In other words, the *navāṃśaka* is likely a product of the amalgamation of the two systems.

⁶³ For a discussion of the periodization of Indian astral science based on the extant Sanskrit materials together with evidences from contemporaneous Chinese translations, see Mak 2015: 1-19. One may note with curiosity as well as with consternation the recent trend of the indiscriminate use of the term "Vedic" to designate this form of later, Indianized astral materials exemplified by the Greco-Indian horoscopy, which is chronologically a derivative of its Hellenistic precedents. The Vedic astral tradition was characterized by lunar astrology and the use of the twenty-seven/twenty-eight *nakṣatras*, in contrast to horoscopy, which was dependent on a body of preexistent planetary science, disseminated and developed in India at around the early centuries of the common era. Unless one defines "Vedic" so broadly that it covers everything Indian, "Vedic astrology" as a designation for works of the *horā* genre is not only a misnomer, but does also great injustice to the historical understanding of the evolution of Indian scientific literature enlightened to us by earlier Western and Indian scholars.

divergent views on the subject and were quoted by both Varāhamihira and subsequently Utpala. By including the actual references in his commentary, Utpala seems not so much as to validate the sixth-century work of Varāhamihira, which was by then already an authoritative work, but to demonstrate his erudition. Furthermore, as Zysk observed, as part of the Brahmanization of the text, Utpala emended the reading of these citations so that they may conform to his Sanskrit learning both in content and in form (i.e., Pāṇinian grammar, versification, etc.).⁶⁴ Ultimately, the commentator eliminated traces of older Prakritism or the Greek which underlay some of the technical vocabulary.

Doubtless, the trajectory of Indianization took place much earlier before Utpala, from the moment the foreign ideas were versified in Sanskrit, with the example of Varāhamihira's very own attempt to etymologize *horā* ("ascendent" from *ὄρα*) as an abbreviation of *ahorātra* ("nycthemeron," lit. "day-and-night").⁶⁵ However, what Utpala achieved in his commentary, besides the didactic intent (formulaic glosses, explanatory headings and the identification of meters) was to connect the contents of the text to all available sources, in a manner in between the modern-day footnote and the "hypertext," where related texts are linked with or without explanations to form a repository of data. The fact that the works of only a few authors mentioned by Varāhamihira survive in their entirety and that in many instances Utpala's references to them remains our sole source, make the *Jagaccandrikā* all the more valuable. Among over 360 instances of works cited by Utpala, forty sources can be identified.⁶⁶ The most frequently cited texts are Sphujidhvaja's *Yavanajātaka* (YJ), followed by Kalyāṇavarman's *Sārāvalī*, *Garga[samhitā]*, and the works of Satya, Bādarāyaṇa and Maṇittha. It may be noted that while Utpala succeeded in tracing the sources of a number of authors Varāhamihira mentioned (Satya, Maṇittha, Viṣṇugupta, Devasvāmin and Jīvaśarman), the frequently cited texts of Sphujidhvaja, Kalyāṇavarman and Garga were never explicitly referred to in BJ itself.

Utpala's quotation of YJ is particularly important due to the scarcity of its

⁶⁴ As Zysk observed in the commentaries of Utpala, Yogīśvara and Mitramiśra, there are textual alterations in the form of "literary embellishment, grammatical corrections and... [incorporation of] terminology appropriate to each author's brahmanic intellectual milieu." Zysk 2016: 463, 468-9. 486.

⁶⁵ *horety ahorātravikalpam eke vāñchanti pūrvāparavarṇalopāt* (BJ 1.3a). One may argue that Varāhamihira had some doubt in this interpretation given the *eke* in the verse, though he showed no objection to it.

⁶⁶ Appendix B.

manuscript.⁶⁷ Together with Bhāskara’s commentary (629 CE) to the *Āryabhaṭīya*, Utpala’s commentary serves as a crucial witness to the text. In addition, Utpala offers us the insight that Yavaneśvara was an epithet of Sphujidhvaja.⁶⁸ Together with other evidences, Pingree’s widely accepted dating of the “translation” and “versification” of the text (149/150 CE and 269/270 CE) should be refuted.⁶⁹ Furthermore, although “Yavaneśvara-Sphujidhvaja” appears to be one of Utpala’s main references, it should be noted that the “Yavana” Varāhamihira referred to comes most likely from a different source, as pointed out by Utpala in the following example:⁷⁰

... *evam sphujidhvajakṛtam śakakālasāyārvāg jñāyate | anyac ca yavanācāryaiḥ pūrvaiḥ kṛtam iti tadarthaṃ sphujidhvajo 'py āha | yavanā ūcuḥ | ye saṃgrahe digjanajātibhedāḥ proktāḥ purāṇaiḥ kramaśo grahasya* (YJ 1.27) | *tad etaj jñāyate yathā varāhamihireṇa pūrvayavanācāryamatam evopanyastam asmābhis tan na dṛṣṭam | sphujidhvajakṛtam eva dṛṣṭvā parāśarasyāpīyam eva vārtā | pārāśarīyā saṃhitā kevalam asmābhir dṛṣṭā na jātakam* |⁷¹

[Translation] [commenting on the interpretation of “lifespan attribution” (*āyurdāya*) attributed to the Yavana by Varāhamihira but not found in Yavaneśvara-Sphujidhvaja’s work] ... thus it is known that [the *Yavanajātaka*] was composed by Sphujidhvaja after the Śaka era. Another [work] was composed by the past Yavana teacher (before Sphujidhvaja).⁷² Exactly for that reason, Sphujidhvaja says, “The Yavana-s said” [as stated in the *Yavanajātaka*:] “The various kinds of places and people pertaining to (each) planet have been briefly recounted in order by the

⁶⁷ Up until Yano’s discovery of another copy of YJ, mislabeled under *Bṛhadayavanajātaka* in the NGMPP collection in 2011, the NGMPP manuscript A31/16 was our only original source of the text, which was the basis of Pingree’s 1978 edition (Mak 2013: 60-62).

⁶⁸ Ibid. Thus with expressions such as *yavaneśvareṇa sphujidhvajenānyacchāstram kṛtam* (BJ 7.9). Since similar usage is found also in Bhāskara’s commentary and no contrary evidences suggest otherwise, there is no reason to take the two names found in the last verses of YJ as two different individuals as Pingree did (Mak 2013: 72).

⁶⁹ Ibid., 68-74.

⁷⁰ Utpala observes that even Sphujidhvaja attributed some of his teachings to the earlier *yavana*(s). The word *yavana-* appears twenty times in YJ. In all cases, they were either part of a compound, as in *yavanābhidhānam* (1.49b) or in plural, as in *yavanair niruktāḥ* (1.61d).

⁷¹ Commentary on BJ 7.9.

⁷² Although *yavanācāryaiḥ* was given in plural, the list of authors Varāhamihira gave suggested that the *yavana-* he had in mind was a single author, which according to Pingree should be Mīnarāja (Pingree 1978: I.24). I thank Slaje for pointing out the use of *pluralis majestatis* in the śāstric tradition.

ancients...’’⁷³ It is known therefore that what was laid down as the opinion of the ancient Yavana teacher according to Varāhamihira [in his *Bṛhajjātaka*] is not available to us. Having seen Sphujidhvaja’s work, this [*Jātaka*?] is precisely also a rendition (*vārttā*) of Parāśara’s work.⁷⁴ Only the *Samhitā* of Parāśara is available to us, but not the *Jātaka*.

Furthermore, BJ contains obscure Greek loanwords as in the names of the zodiacal signs (Table 1), most of which are attested in neither YJ nor the *Vṛddhayavanajātaka* of Mīnarāja (VYJ):

kriyatāvurijitumakulīraleyapāthonajūkakaurpyākhyāḥ |
tauṣika ākokero hṛdrogaś cāntyabhaṃ cettham || (BJ 1.8)

[Translation with Utpala’s gloss in round brackets] [The signs] are called *kriya* (Aries), *tāvuri* (Taurus), *jituma* (Gemini), *kulīra* (Cancer),⁷⁵ *leya* (Leo), *pāthona* (Virgo), *jūka* (Libra), *kaurpi* (Scorpio), *tauṣika* (Sagittarius), *ākokero* (Capricorn), *hṛdroga* (Aquarius), and the last sign is *ittham* (“thus”).

Table 2 Zodiacal signs in English, Greek and Sanskrit according to Varāhamihira

English	Greek	Greek loans in Sanskrit	Sanskrit (Utpala’s gloss)
Aries	κρίος	kriya	meṣa
Taurus	ταῦρος	tāvuri	vṛṣa
Gemini	δίδυμοι	jituma	mithuna
Cancer	καρκίνος	karki	karkaṭa
Leo	λέων	leya	siṃha
Virgo	παρθένος	pāthona	kanyā

⁷³ YJ 1.27 ab (Pingree trans.). Nb. ed. reads [*grha*]sya, thus “sign” instead of “planet.”

⁷⁴ The line appears to be corrupt. What Utpala suggests here is likely that by comparing the works of Sphujidhvaja and Varāhamihira, one can see that there are works older than Sphujidhvaja’s before the Śaka era. Utpala suggested that the *Samhitā* of Parāśara was the main source of BS, just as an older works of Yavana (also Parāśara) would be the source of BJ. Utpala stated however that he had no access to the *Jātaka* of Parāśara. I thank Zysk’s comment for suggesting to me various possibilities of interpretation.

⁷⁵ Cancer in Sanskrit is more common as *karki* (BJ 1.10, YJ 1.8) which is cognate with or borrowed from καρκίνος (Cancer), rather than *kulīra*. While the remaining names in the list are all Greek loanwords, Varāhamihira must have not chosen *kulīra* for metrical reasons and considered the two terms as synonyms. There is however at least one instance in the *Atharvavedaparīṣiṣṭa* where *kulīra* and *karkaṭa* appear to designate different animals: *sauvarṇau kūrmamakarau rājatau matsyamudgarau | tāmrau kulīrakarkaṭāv āyasaḥ śiśumārakah ||* (Bolling & von Negelein ed., 1909-1910, 39.1.10).

Libra	ζυγόν	jūka	tulā
Scorpio	σκορπίος	kaurpi	vṛścika
Sagittarius	τοξότης	tauṣika	dhanvin
Capricorn	αιγόκερως	ākokera	makara
Aquarius	ύδροχόος	hṛdroga	kumbha
Pisces	ιχθύες	ittham	evam [sic]

Commenting on this verse, Utpala provided the correct Sanskrit equivalent for all the signs (*meṣa*, etc.) except curiously, the last one *ittham*, which was incorrectly glossed as *evam* (“thus” = *ittham*) as Yano pointed out.⁷⁶ The lapse indicates that Utpala had no knowledge of Greek and was unaware of the foreign lexicons, assuming thus their native, though obscure origin.⁷⁷

4. Conclusion

The textual materials shown in the foregoing discussion reveal that by the tenth century, Greco-Indian astral texts composed by Maya, Garga, Parāśara, Satya, Sphujidhvaja, Maṇittha and others were preserved and transmitted in Kashmir. Utpala’s collection of these texts and his effort to consolidate them reveal the rich *jyotiṣa* tradition Kashmir nurtured, as corroborated by al-Bīrūnī’s testimony. More broadly speaking, what Utpala achieved in his commentaries was to subsume the divergent *jyotiṣa* traditions under one of his own, in the fashion of a true polymath, thus following in the footsteps of his predecessor Varāhamihira. The commentaries serve not only to unravel Varāhamihira’s works, but to provide a legitimate framework for Utpala to present his interpretations, which include elements of the local Kashmiri traditions. As we have seen, Utpala’s attempt was overwhelmingly successful. These works of Varāhamihira have been subsequently transmitted almost exclusively with Utpala’s commentaries, unrivalled by others. One can argue that the Indian

⁷⁶ Yano 1987: 80. It may be noted that Utpala, after glossing Aquarius with *hṛdrogaḥ kumbhaḥ*, supplies *antyabhaṃ mīna itī* (“The last zodiacal sign is Pisces”) despite failing to gloss *ittham*. The gloss is followed by: *prayojanaṃ ca | gosimhau jītumāṣṭamau kriyatule ityādi* (“And the purpose is to explain [verses] such as Taurus-Leo Gemini-8th sign Aries-Libra [BJ 26.9a]...”). Here, Utpala shows that such unusual terms are found elsewhere in the same work of Varāhamihira, who used these words and numbers interchangeably *metri causa*.

⁷⁷ Similar instances of obscure Greek loanwords in Sanskrit unattested elsewhere are found throughout BJ; it is therefore not unreasonable to surmise that this work of Varāhamihira comes from a different lineage than the two known Greco-Indian works of Mīnarāja and Sphujidhvaja. For a proposal of the relationship between the three major Greco-Indian *jātaka* texts, namely VYJ, YJ and BJ, see Mak 2018: 12.

astral tradition, which started off as a highly divergent one at the beginning of the first millennium with many voices and ostensibly foreign Hellenistic influences, culminated by the end of the millennium and was finally absorbed into the monolithic Sanskrit learning of the Brahmins. Following the trajectory of Indianization, or more precisely, “Brahminization,” Utpala created a corpus of authoritative commentaries and heralded a new orthodoxy which was to last for the next millennium up to the present.

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Abbreviations

- BJ : *Bṛhajjātaka* by Varāhamihira (Jhā ed.)
 BS : *Bṛhatsaṃhitā* by Varāhamihira (Dvivedin/Tripāṭhī ed.)
 BSS : *Brāhmasphūṭasiddhānta* by Brahmagupta (Sharma ed.)
 CESS : *Census of the exact sciences in Sanskrit*, edited by David Pingree, five volumes (A1-5), American Philosophical Society, Philadelphia, 1970-1994.
 KhKh : *Khaṇḍakhādyaka* by Brahmagupta (Chatterjee ed.)
 PS : *Pañcasiddhāntikā* by Varāhamihira (Kuppanna Sastry ed.; also Pingree and Neugebauer ed.)
 RT : *Rājatarāngiṇī* by Kalhaṇa (Stein trans.)
 VYJ : *Vṛddhayavanajātaka* by Mīnarāja (Pingree ed.)
 YJ : *Yavanajātaka* by Sphujidhvaja (Pingree ed.)

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Appendix A⁷⁸Citations in *Samhitāvivṛti*

	Text	Counts	vv.
1	Unknown	206	487.75
2	Āryabhaṭa	9	14
3	Rṣiputra	11	25.5
4	Kaṇāda	2	1.25
5	Kapila	1	9
6	Kaśyapa	25	34.5
7	Kātyāyana	1	0.5
8	Kāmandaki	1	5.5
9	Kāśyapa	99	260
10	Kiraṇākhyatantra	8	15.5
11	Garga	189	448
12	Golaśāstra	2	6
13	Caraka	1	0.5
14	Chandomañjarī	27	14.5
15	Tantra	6	8.5
16	Devala	7	11.5
17	Nagnajit	2	1.5
18	Nandi	5	5.5
19	Nārada	1	1
20	Nighaṇṭu	1	36
21	Pancasiddhāntikā	44	120
22	Parāśara	206	132 ⁷⁹
23	Pāṇini	2	1
24	Purāṇakāra	4	54
25	Puliśa	11	17
26	Balabhadra	3	9
27	Bādarāyana	5	5
28	Bṛhājāta	22	24
29	Bṛhadyātrā	8	21
30	Bṛhaspati	3	5

31	Brahmasiddhānta	29	47.5
32	Bhaṭṭotpala	5	10.5
33	Bhadrabāhu	1	4
34	Bharadvāja	1	1
35	Bhānubhaṭṭa	1	1
36	Bhṛgu	1	1
37	Manu	4	16
38	Maya	2	2
39	Māṇḍavya	1	4
40	Yama	1	2
41	Yavaneśvara	24	61
42	Yātrākāra	2	5
43	Yogayātrā	1	5
44	Laghujāta	1	1
45	Laukāyatikā	1	1
46	Vararuci	3	7
47	Vasiṣṭha	2	3
48	Viśvakarman	10	27
49	Viṣṇucandra	1	1
50	Vīrabhadra	1	1
51	Vṛttaratnākāra	2	0.75
52	Vṛddhagarga	35	76
53	Vyāsa	6	8
54	Śakra	1	1.5
55	Śālihotra	2	2
56	Śruti	1	0.5
57	Samāsasaṃhitā	71	142.5
58	Samudra	11	21.5
59	Sārasvata	17	31
60	Sārāvalī	9	18
61	Siddhasena	1	1
62	Sūryasiddhānta	4	5
63	Smṛti	1	0.5
64	Hiraṇyagarbha	5	16
		1170	2300

⁷⁸ Sugita 1992:14-16.⁷⁹ Plus 667 prose lines.

Appendix B⁸⁰Citations in *Jagaccandrikā*

	Text	Counts	vv.
1	Unknown	25	25.5
2	Amarakośa (?)	1	0.25
3	Ṛgveda	1	1
4	Garga	39	65.5
5	Candradīpikā	1	1
6	Caraka	1	1
7	Jīvaśarman	3	4
8	Tikanikayātra	1	1
9	Balabhadra	1	3
10	Bādarāyaṇa	23	21.25
11	Bṛhatsaṃhitā	12	29.5
12	BS/Yogayātrā	1	5
13	Bṛhadyātrā	8	20
14	Brahmagupta (BSS)	2	2
15	Brahmagupta (KhKh)	1	1
16	Bhāskarasiddhānta	1	1
17	Devakīrti	4	5
18	Devasvāmin	1	1
19	Maṇittha	12	14.75
20	Māṇḍavya	8	10
21	Manu	1	1
22	Maya	2	4
23	Pañcasiddhāntikā	1	1
24	Parāśara(saṃhitā)	1	0.25
25	Pulisa(siddhānta)	2	1.5
26	Yajñavalkyasmṛti	2	1.25
27	Yama	1	1
28	Yavanajātaka	64	73.5
29	Yogayātrā	1	0.5
30	Vivāhapaṭala	1	0.5

31	Viṣṇugupta	2	2
32	Veda	1	0.25
33	Vedāṅgajyotiṣa	1	1
34	Vyāsa	2	1.5
35	Laghujātaka	30	44.25
36	Śaṅkara	1	2
37	Śrutakīrti	6	7
38	Ślokavārttika	1	3
39	Satya	34	68
40	Sārāvalī	60	112.75
41	Siddhasena	1	1
	Total	361	540

⁸⁰ Based on notes taken from Yano/Mak BJ reading sessions 2012.5.15 - 2015.9.8.

Appendix C Utpala's commentary on BS 2(3)

tatreti | tatra tasmin grahaganīte
pañcasiddhāntā bhavanti | ke te
paulīśaromakavāsiṣṭhasaurapaitāmahāḥ
puliśasiddhāntaḥ romakasiddhāntaḥ
vāsiṣṭhasiddhāntaḥ sūryasiddhāntaḥ
brahmasiddhānta itī | eteṣu siddhānteṣu
pañcasu vettā `bhijñāḥ |
yugavarṣāyanartumāsa-
pakṣāhorātrayāmamuhūrtanāḍīvināḍīprānātru
tīrutryādyavayavasya kālasya vettā |

yugānām kṛtatretādvāparakalīnām
pramāṇajñāḥ | yathaitāvadbhīḥ saurair varṣaiḥ
kṛtayugaḥ bhavati etāvadbhis tretā
etāvadbhir dvāparam etāvadbhīḥ kalir itī |
tadyathā khakhakhadantābdhayāḥ
kaliyugaparimāṇam bhavati | etaiḥ sarvair
ekīkṛtya caturyugapramāṇam bhavati |

tathā ca brahmasiddhānte |
khacatuṣṭayaradavedā 4320000 ravivarṣānām
caturyugaḥ bhavati | sandhyāsandhyāmśaiḥ
saha catvāri pṛthak kṛtādīni ||
yugadaśabhāgo guṇitāḥ kṛtaḥ caturbhis
tribhir guṇas tretā | dviguṇo dvāparam ekena
saṃguṇaḥ kaliyugaḥ bhavati ||

tathā ca pulīśasiddhānte divyena mānena
paṭhyante –
aṣṭācatvāriṃśat pādavihīnā kramāt kṛtādīnām
| abdās te śataguṇitā grahatulyayugaḥ tad
ekatvam || itī |

tadyathā – 4800 | 3600 | 2400 | 1200 | ete
divyena mānenātaḥ
ṣaṣṭīsamadhikaśatatrāyeṇa guṇitā jātāḥ
1728000 kṛtam | 1296000 tretā | 864000
dvāparam | 432000 kalih | evam yugānām
vettā |

1. On “with respect to that” – That refers to the astronomical treatise, on the subject of which there is the *Pañcasiddhāntāḥ* (“Five astronomical treatises”). They are: *Paulīśa*, *Romaka*, *Vāsiṣṭha*, *Saura* and *Paitāmaha*, referring to *Puliśasiddhānta*, *Romakasiddhānta*, *Vāsiṣṭhasiddhānta*, *Sūryasiddhānta*, and *Brahmasiddhānta* respectively. [An astronomer should be a] knower of these five astronomical treatises, a knower of temporal units such as *yuga*, year, half-year (*ayana*), seasons, *pakṣa*-s, nycthemeron (*ahorātra*), *yāma*, *muhūrta*, *nāḍī*, *vināḍī*, *prāna*, *truṭī*, and divisions such as *truṭī*.

2a. One should know that a *yuga* consists of [the four periods] *kṛta*, *tretā*, *dvāpara* and *kali*. Since the *kṛtayuga* consists of solar (sidereal) years, and so are the [*yuga*-s] *tretā*, *dvāpara* and *kali*, therefore, the length of *kaliyuga* would be 432000 [years]. Combining them together, [the great *yuga*] consists of four *yuga*-s.

2b. Thus it is explained in the *Brahmasiddhānta*: The quadruplicate [great] *yuga* has 4320000 years. The four [*yuga*-s] starting from *kṛta* each have periods of conjunction and disjunction. A tenth of the [great] *yuga* multiplied by four is [the duration of] *kṛta*, multiplied by three is *tretā*, multiplied by two is *dvāpara*, multiplied by one is the *kaliyuga*.

2c. As far as *Puliśasiddhānta* is concerned, [the values] should be interpreted by the “divine measures”:⁸¹
The years of [the four *yuga*-s starting with] *kṛta* are obtained by subtracting a quarter progressively from 4800 respectively, that is [the years it takes] for the conjunction of the planets to reach complete unison.

2d. Therefore, 4800, 3600, 2400, 1200 by the “divine measure” are multiplied by 360 which result in 1728000 for *kṛta*, 1296000 for *tretā*, 864000 for *dvāpara*, 432000 for *kali*. Thus one should know the *yuga*-s.

⁸¹ Pingree 1969: 180.

yavatā kālenārko dvādaśarāśīkaṃ bhacakram
meṣādīmīnāntaṃ bhuñkte tadvarṣaṃ tena
sauravarṣapramāṇena yugasamkhyānam |
evam ravirāśibhogo māsaḥ | dvādaśabhir
māsair varṣam iti | tathā ca brahmasiddhānte
nṛvatsaro 'rkābdaḥ iti|

ayane dakṣiṇottare ṣaḍbhīḥ sūryamāsair
uttaram ayanam ṣaḍbhir dakṣiṇam iti | tatra
makarādirāśiṣaṭkasthe uttaram ayanam
karkyādirāśiṣaṭkasthe dakṣiṇam iti |

ṛtavaḥ ṣaḍ bhavanti śiśirādayaḥ | te ca
māsadvayātmakāḥ | tadyathā –
makarakumbhasthe 'rke śiśirāḥ |
mīnameṣasthe vasantaḥ | vṛṣamithunasthe
grīṣmaḥ | karkaṭasiṃhasthe varṣāḥ |
kanyātulāsthe śarat | vṛścikadhanvisthite
hemanta iti |

tathā cācāryaḥ -
udagayanaṃ makarādāv ṛtavaḥ śiśirādayaś ca
sūryavaśāt | dvibhavanakālasamānā dakṣiṇam
ayanam ca karkaṭakāt ||

tathā ca brahmasiddhānte –
dvau dvau rāśī makarād ṛtavaḥ ṣaṭ
sūryagatīvaśād yojyāḥ | śiśiravasanta-
grīṣmavarṣāśaradaḥ sahemantāḥ || iti

māsaś caitrādikāḥ | sa ca ravirāśibhogas
triṃśaddinātmakāḥ | pakṣo māsārdham
pañcadaśa dināni | ahorātram ṣaṣṭir ghaṭikāḥ |
yāmo 'horātrāṣṭamabhāgaḥ | dinasya
caturthabhāgo rātreś ca | muhūrto 'hnaḥ
pañcadaśamśaḥ rātreś ca pañcadaśabhāgaḥ |
nāḍī ghaṭikā 'horātraṣaṣṭyamśaḥ | vināḍī
vighaṭikā ghaṭikāṣaṣṭyamśaḥ | prāṇaḥ
śvāsanirgamapraveśau | truṭīś
cakṣumimeṣadvayam | trutyādyavayavas
tadartham | ādigrahaṇāt truṭīcaturthabhāgam
api | evam ādikasya vettā |

The time it takes for the sun to traverse the celestial
sphere of twelve zodiacal signs, which begins with
Aries and ends with Pisces is a [sidereal] year. The
reckoning of *yuga* is made with the unit of solar
[sidereal] year. A month is the duration of the Sun in
a sign and thus a year consists of twelve months.
Thus in the *Brahmasiddhānta*, a human year
“*nṛvatsara*” is a solar year.

3a. With respect to the northern or southern *ayana*,
the northern *ayana* takes six solar months, and the
southern takes six. There, the northern *ayana* is the
six signs starting from Capricorn while the southern
one is the six signs starting from Cancer.
The six seasons are *śiśira* (chilly season) and so on.
They each contain two months. Thus *śiśira* is when
the Sun is in Capricorn and Aquarius; spring
(*vasanta*) when [the Sun is] in Pisces and Aries; hot
season (*grīṣma*) when [the Sun is in] Taurus and
Gemini; rainy season (*varṣa*) when [the Sun is in]
Cancer and Leo; autumn (*śarad*) when [the Sun is
in] Virgo and Libra; *hemanta* (cold season) when
[the Sun is in] Scorpio and Sagittarius.

3b. Thus according to the **teacher** (PS 3.25):
The Sun's turning northward is when it reaches the
beginning of Capricorn, [and this is when] the
seasons *śiśira* and so on [commence]. Its turning
southward is at [the beginning of] Cancer. Each
season lasts the duration of two signs (i.e., tropical
solar months).

3c. Furthermore, according to the
Brahmasiddhānta: The seasons, *śiśira* and so on
(commence with the winter solstice,) each have the
duration of two signs (i.e., two solar months).

4a. A month is *Caitra* and so on. Moreover, it
consists of thirty days and is the duration of the
sun[’s transit in a] sign. A *pakṣa* is half a month or
fifteen days. A *nychthemeron* is sixty *ghaṭika*-s. A
yāma is one eighth of a *nychthemeron*, or a quarter
of the day and the night. A *muhūrta* is a fifteenth of
the day or a fifteenth of the night. A *nāḍī* or a
ghaṭikā is a sixtieth of a *nychthemeron*. A *vināḍī* or
a *vighaṭikā* is a sixtieth of a *ghaṭikā*. A *prāṇa* is
made up of an out-breath and an in-breath. A *truṭi* is
two blinks (*nimeṣa*) of the eye. The “division of
truṭi and so on” has the meaning of that. The
expression *ādi* (“so on”) can also mean a quarter of
truṭi. In such a way, one should understand *ādika*.

Tathā ca bhagavān parāśaraḥ |

yāvātā kālena vikṛtam akṣaram uccāryate sa
nimeṣaḥ | nimeṣadvayaṃ truṭiḥ | truṭidvayaṃ
lavaḥ | lavadvayaṃ kṣaṇaḥ | daśa kṣaṇāḥ
kāṣṭhā | daśa kāṣṭhāḥ kalā | daśa kalā nāḍikā |
nāḍikādvayaṃ muhūrtaḥ | triṃśanmuhūrta
dinam iti |

evaṃ kālasya vettā | tathā kṣetrasya vettā |
tatra kālakṣetrayoḥ sāmānyam | tadyathā | kāle
ṣaṭ prāṇā vighaṭikā | vighaṭikānāṃ ṣaṣṭya
ghaṭikā | ghaṭikānāṃ ṣaṣṭya dinam | dinānāṃ
triṃśatā māsaḥ | māsaḥ dvādaśabhir varṣam
bhavati | atha kṣetre | ṣaṣṭya tatparāṇāṃ
viliptā bhavati | viliptānāṃ ṣaṣṭya liptā |
liptānāṃ ṣaṣṭya bhāgaḥ | bhāgānāṃ triṃśatā
rāśiḥ | rāśidvādaśakaṃ bhagaṇa iti |

tathā ca brahmasiddhānte |
prāṇair vināḍikā ṣaḍbhir ghaṭikaikā
vināḍikāṣaṣṭya | ghaṭikāṣaṣṭya divaso
divasānāṃ triṃśatā māsaḥ || māsaḥ dvādaśa
varṣam vikalāliptāṃsaraśibhagaṇāntaḥ |
kṣetravibhāgas tulyaḥ kālena vināḍikādyena ||

tathā ca paulīse |
ṣaṭprāṇās tu vināḍi tat ṣaṣṭya nāḍikā dinam
ṣaṣṭya | etāsāṃ tat triṃśan māsaḥ tair
dvādaśabhir abdaḥ || ṣaṣṭya tu tatparāṇāṃ
vikalā tatṣaṣṭir api kalā tāsām | ṣaṣṭyaṃśas te
triṃśad rāśis te dvādaśa bhacakram ||

tathā cāryabhaṭaḥ -
varṣam dvādaśa māsaḥ triṃśad divaso bhavet
sa māsaḥ tu | ṣaṣṭir nāḍyo divasaḥ ṣaṣṭis ca
vināḍikā nāḍi || gurvakṣarāṇi ṣaṣṭir
vināḍikārṣi ṣaḍ eva vā prāṇāḥ | evaṃ
kālavibhāgaḥ kṣetravibhāgas tathā bhagaṇāt ||

anyad apy āha |

4b. Furthermore, according to the venerable

Parāśara:

A *nimeṣa* is the time it takes for an isolated syllable to be uttered. A *truṭi* is two *nimeṣa*-s. A *lava* is two *truṭi*-s. A *kṣaṇa* is two *lava*-s. A *kāṣṭhā* is ten *kṣaṇa*-s. A *kalā* is ten *kāṣṭhā*-s. A *nāḍikā* is ten *kalā*-s. A *muhūrta* is two *nāḍikā*-s. A day is thirty *muhūrta*-s.

5a. In such a way, one should know the temporal units. One should know the spatial units as follows. The temporal and spatial units are identical. Therefore, as far as temporal units are concerned, a *vighaṭikā* has six *prāṇā*-s. A *ghaṭikā* has sixty *vighaṭikā*-s. A day has sixty *ghaṭikā*-s. A month has thirty days. A year has twelve months. As for the spatial units, a *viliptā* has sixty *tatpara*-s. A *liptā* has sixty *viliptā*-s. A degree (*bhāga*) has sixty *liptā*-s. A sign has thirty degrees. One celestial revolution (*bhagaṇa*) is twelve signs.

5b. Furthermore, according to the **Brahmasiddhānta:**

A *vināḍikā* has six *prāṇā*-s. One *ghaṭikā* has sixty *vināḍikā*-s. A day has sixty *ghaṭi*-s. A month has thirty days. A year has twelve months. The spatial units are consisted of *vikalā*, *liptā*, degree (*aṃśa*), sign and celestial revolution, which are equivalent to the temporal units starting from *vināḍikā*.

5c. Furthermore, according to **Paulīsa[siddhānta]**:⁸²

A *vināḍi* is six *prāṇā*-s. A *nāḍikā* has sixty [*vināḍi*-s]. A day has sixty [*nāḍikā*-s]. A month has thirty [days]. A year has twelve [months]. A *vikalā* has sixty *tatpara*-s. A *kalā* has sixty [*vikalā*-s]. A degree has sixty [*kalā*-s]. A sign has thirty [degrees]. A celestial revolution is twelve signs.

5d. Furthermore, according to **Āryabhaṭa:**

A year is twelve months. A month is thirty days. A day is sixty *nāḍi*-s. A *nāḍi* is thirty *vināḍikā*-s. A *vināḍikā* is sixty heavy syllables. Alternatively, an *ārṣi* has six *prāṇā*-s. Thus are the temporal division and spatial division from within a celestial revolution.

[Other astronomers] have also said otherwise.

⁸² Pingree 1969: 179.

Appendix D

Systems of time unit according to Bhaṭṭotpala and al-Bīrūnī

(I) Utpala's system according to his commentary to BS 2(3). Borders in bold indicate the correspondence between the parts in (I) and (II)/(III).

	tru°ādi	ni	tru	prā	vi	gha	ny
truṭyādi	1						
nimeṣa	(2)	1					
truṭi	4	2	1				
prāṇa	(~44.4)	(~22.2)	(~11.1)	1			
vighaṭikā	(266 $\frac{2}{3}$)	(133 $\frac{1}{3}$)	(66 $\frac{2}{3}$)	(6)	1		
ghaṭikā	(16000)	(8000)	(4000)	(360)	60	1	
nychthemeron	(96000)	(480000)	(240000)	(21600)	(3600)	60	1

(II) Parāśara's system

	nim	tru	la	kṣa	kāṣ	kalā	nā	mu	ny
nimeṣa	1								
truṭi	2	1							
lava	4	2	1						
kṣaṇa	8	4	2	1					
kāṣṭhā	80	40	20	10	1				
kalā	800	400	200	100	10	1			
nādikā	8000	4000	2000	1000	100	10	1		
muhūrta	16000	8000	4000	2000	200	20	2	1	1
nychthemeron	480000	240000	120000	60000	6000	600	60	30	1

(III) System according to *Brahmasiddhānta* (=Brāhmasphūṭasiddhānta), *Paulīśasiddhānta*, *Aryabhaṭīya*

	prā	vi	gha	ny
prāṇa	1			
vighaṭikā/vinādikā	6	1		
ghaṭikā/nādikā	360	60	1	
nychthemeron	21600	3600	60	1

(IV) Recommended system proposed by al-Bīrūnī according to the “theory of Utpala and ŚMY” (I.337)

	a	tru	la	ni	prā
aṇu	1				
truṭi	8	1			
lava	64	8	1		
nimeṣa	512	64	8	1	
prāṇa	4096	512	64	8	1

