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The Last Chapter of Sphujidhvaja's *Yavanajātaka* critically edited with notes[1]

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Abstract

Since its discovery by scholars in the late nineteenth century, the last chapter of Sphujidhvaja's *Yavanajātaka* has been known as one of the earliest extant specimens of Indian astronomical works composed in Sanskrit. Subsequently, thanks to David Pingree's 1978 edition of the text, this chapter became widely recognized as one of the earliest Greek astronomical texts translated into Sanskrit, revealing the remarkable connection between the Greco-Babylonian astral science and the Indian one. However, some of Pingree's claims had been disputed by scholars and Pingree's reading and interpretation of the primary materials have been challenged by scholars such as Shukla (1989) and Falk (2001). In the light of the discovery of a new Nepalese paper manuscript and some other additional materials, some of the lacunae may now be filled and the additional variant readings have given us further clues to an improved interpretation of the text. The present study provides a summary of all the new findings concerning the last chapter of the *Yavanajātaka*, together with a revised, annotated critical edition.

[1] I would like to thank all the scholars who kindly offered their help and advices during the course of this research. First and foremost, it was Professor Yano Michio who introduced me to the *Yavanajātaka* and read with me and his students its beginning chapters in early 2010. Professor Yano was also the first to inform me in August 2011 about his discovery of the new manuscript Q in the collection of the Nepal-German Manuscript Preservation Project (NGMPP) during his trip to Nepal. The color copies of mss. Q and N were provided to me by Michio Yano, with the facilitation of Professor Harunaga Isaacson and Dr. Albrecht Hanisch. In addition, Professor Isaacson and Dr. Kengo Harimoto provided me the black-and-white copy of N and other fragments titled *Yavanajātaka* in the NGMPP collection. In September 2012, after some lacunae and variants were identified, Professor Harunaga Isaacson read with me parts of the last folios of the manuscripts Q and N. In October 2012, Professor Francesco Sferra informed me about an additional facsimile of N made by Giuseppe Tucci where the missing folio was found and provided me a copy of it. Subsequently, some of the major findings described in this paper were presented during the annual conference of the Association for the Study of the History of Indian Thought (インド思想史学会) held at Kyoto University on 22 December 2012, and were later published in Mak 2013 after receiving suggestions from Professor Alexis Sanderson, Professor Yūko Yokochi, Professor Diwakar Acharya, Professor Somadeva Vasudeva and Professor Dominik Wujastyk. I thank also Professor S. R. Sarma and Professor Takao Hayashi for their extremely thorough comments and suggestions on a draft of this paper during its final stage. Needless to say, all remaining errors are of my sole responsibility.

I. Introduction

In 1978, David Pingree published his edition and translation of Sphujidhvaja's *Yavanajātaka*. The text soon established itself as one of the most important historical documents in various fields of Indology, from the history of mathematics and astral science, to Indian chronology and historical contacts among ancient cultures. A number of Pingree's claims concerning the text has been widely quoted by scholars in the past decades. These claims may be summarized as follows: The *Yavanajātaka* was an astrological/astronomical work composed in 269/270 CE by Sphujidhvaja, an "Indianized Greek" who lived in the realm of the Western Kṣatrapas. The work was a versification of a prose original in Greek composed by Yavaneśvara in Alexandria in 149/150 CE. The work, though highly corrupt and clumsily expressed, contains algorithms of "ultimately Babylonian origin", the earliest use of *bhūtasaṃkhyā*, as well as the earliest reference to the decimal place-value with a symbol for zero (*bindu*).

Pingree's claims were based largely on readings from the last section of the *Yavanajātaka*, described by him as "Chapter 79 - Horāvidhiḥ", an exposition of mathematical astronomy. Although scholars including Shukla and Falk have pointed out some major flaws in Pingree's interpretations and reconstitution of the text, further progress of a proper reevaluation of the controversial contents of this chapter has so far been hampered by the lack of better source materials. In 2011-2012, additional materials including a hitherto unreported manuscript of the *Yavanajātaka* were discovered by Yano Michio and discrepancies between Pingree's edition and readings from both the new and the old manuscripts were identified by the present author.[2] This paper will therefore be a new attempt to reexamine Pingree's key interpretations of the *Yavanajātaka*, focusing on this last chapter, in the light of the new textual evidences which have so far not been considered.

II. Textual sources

The additional textual materials used in this paper are of two main varieties: i) alternate copies of the Nepalese manuscript N, which was the basis of Pingree's edition, as well as other unreported copies of the *Yavanajātaka*;[3] ii) additional parallel texts and testimonia not mentioned by Pingree.

II.1 Manuscripts

The manuscript N is so far the most complete source of the *Yavanajatāka* extant and it is the only source where all chapters of the work are included, partially or entirely. It was first described, together with a transcription of the last four verses, by H.P. Shastri in

[2] Mak 2013: 4.

[3] See below for a complete description of all the manuscripts.

1897, following R. Mitra's initial survey of palm-leaf manuscripts in the Mahārāja's Durbar library.[4] Subsequently, Shastri himself and P.V. Kane (1955) continued to decipher the text.[5] A copy of transcript of the manuscript N (ff. 2-10, 98-103) was made available to Pingree by Kane in 1958, which eventually became Pingree's K ("Kane"). Together with another manuscript P ("Paris") from Sylvain Lévi's collection, these two manuscripts were used by Pingree to supply readings from the missing f.102. Other manuscript fragments of the *Yavanajātaka* were found by Pingree but their usefulness was reported to be limited. Subsequently, Pingree published the first complete modern edition of the *Yavanajātaka* in 1978.

In his edition of the *Yavanajātaka*, Pingree remarked:

> "The difficulty of editing and understanding Sphujidhvaja arises from the fact that for most of the text we have only one very incorrectly written manuscript to rely on. The errors of N occur, on the average, at least once in every line. Often the expanded version of Mīnarāja or some other testimonium comes to our aid; sometimes a knowledge of Sanskrit grammar or idiom suggests the right reading, although Sphujidhvaja was not so exact in his use of Sanskrit as to make this criterion infallible. So we are occasionally forced simply to guess. And I am aware that I must have missed guesses that will occur to others, and that in some cases I will have guessed wrongly. Non omnia possumus omnes."[6]

The "incorrectly written manuscript" N (folios. 2-103, with f.1 and f.102 missing) used by Pingree was a facsimile of a Nepalese manuscript now in the possession of the National Archives in Nepal.[7] Although I cannot verify the microfilm used by Pingree himself (kept in the archive of Brown University), based on the variants and lacunae reported in the edition, it should be very similar or possibly identical to the black-and-white Nepal-German Manuscript Preservation Project (NGMPP) A31/16 microfilm made on 13 September 1970.

Due to the dilapidated state of the manuscript, the facsimile of N which Pingree's edition was based on was not of the best quality. Unbeknownst to Pingree, Giuseppe Tucci in 1954 also took photos of the same manuscript N. Although the photo quality is poor and is inferior to the black-and-white NGMPP microfilm, it contains the missing f.102 as well as readings at various places which were worn off or corrupt later on.[8]

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[4] Shastri 1897: 310-311.

[5] Shastri 1905: xxix-xxx,40-41;1911: 5-6.

[6] Pingree 1978a: I.22-23.

[7] The manuscript is not dated although the variety of scribbles by different hands (titles, mantras, dedicatory lines, etc.) suggests that it was passed down from a long lineage of astrologers (*jyotiṣika*-s). On orthographic ground, N is probably dated around the twelfth century.

[8] Copies of Tucci's photos as well as relevant documents concerning the circumstances when they were taken were provided to me by Francesco Sferra of Università degli Studi di Napoli "L'Orientale" (Sferra 2008;

In 2011, a set of high-quality digitized color photos of N was made and it provided the best reading among all sources so far, although the condition of the manuscript had further deteriorated. These two new sources become the basis for our attempt to improve on Pingree's reading of N.[9]

In the same year, I was informed by Michio Yano of his discovery of a hitherto unreported copy of the *Yavanajātaka* which was mistakenly recorded as (*Bṛhad)yavanajātaka* in the NGMPP database.[10] A set of digitized color photos was produced (Q). Upon examination, this manuscript is found to contain readings which fill up some lacunae of our copies of N, as well as some significant variants. The manuscript contains seventy-eight folios and was numbered up to ninety, with therefore twelve missing folios. While this manuscript could be as late as the eighteenth century judging from the paper quality,[11] it provides us also some additional information about the text which was not available in N. First of all, the verses were numbered, unlike in N where verses run continuously.[12] As far as the "last chapter" is concerned, Q grouped Ch.77-79 of Pingree's edition into one chapter with 104 verses in total, which is more than 101 verses in N.[13] Secondly, given the fact that Q contains variants sometimes different from N and that the manuscript was copied at such a late date, suggesting that there was a manuscript tradition of the *Yavanajātaka* not directly descended from N, there is a good chance that some other copies similar to Q may still be extant in India and Nepal.

As it turns out, the discovery of Q provides us an opportunity to reexamine all the previous sources used in Pingree's edition of the *Yavanajātaka*. The uniqueness of the work coupled with Pingree's assumption of the corrupt nature of the manuscript as well as generally early Sanskrit jyotiṣa texts, led to his rather free emendations of the YJ,[14] resulting in some highly questionable and some certainly wrong interpretations of the contents of the YJ which ought to be revised.

Nalesini 2008). In addition, Sferra informed me that Pingree confirmed that Tucci's photos contained materials he did not use for his 1978 edition when they were shown to him in the 1990s.

9 ~~N~~$_p$ indicates Pingree's reading of N which is not supported by our manuscript sources.

10 At the top of the first folio of the manuscript marking of "*ṣa 2387 / vidhā / vṛhadyavanajātakam*" in modern ink may be noted. While I cannot verify the particulars concerning this note, it may be noted that Shastri in his report also once described N as "vṛhatyavanajātaka" but later changed to "vṛhatsaṃhitā" (Shastri 1905: xxix-xxx).

11 Diwakar Acharya pointed out to me that although Nepalese paper manuscripts are dated as early as the thirteenth century in the NGMPP collection, Q could be as late as the eighteenth century based on the orthography and the red lines used for alignment.

12 Based on the content of the text, Pingree detected gaps in N by indicating "no space in N" in the apparatus (eg. 79.3c,18b,19ab,30d).

13 The additional three verses are located in the missing pages and cannot be identified.

14 Pingree 1978b: 533-534.

Descriptions of all the known manuscript sources of the *Yavanajātaka* are as follows:[15]

N	NGMPP A31/16 = NAK 1/1180 Palm leaf manuscript. Incomplete. 102 folios (ff. 2-103). 54 × 4.5 cm. Five lines per page. Two binding holes. Old Newarī script (Northern Nāgarī). Twelfth to thirteenth century on orthographical ground (Pingree: beginning of thirteenth century). Representation of sibilants (śa, ṣa, sa) not consistent. Margins damaged and part of the text illegible due to wear and tear. Reproductions: N_t Black-and-white photos taken by Giuseppe Tucci in 1954, ff. 2-103. Tucci 13(XLIX.21-38) and 34(ex35) (XLII.1-9). N_{bw} Black-and-white microfilm prepared by NGMPP in 1970, ff. 2-101, 103. N_c Digitized color photos prepared by NGMPP in 2011, ff. 2-101, 103. K Copy made for P.V. Kane, dated c. 1955, recopied by Pingree in 1958, ff. 2-10, 98-103.[16] (labeled as k by Pingree). Used by Pingree for the missing folio 102. It is not available to me and its content is reported in Pingree's edition. R "A copy of N was apparently made for Hemarāja, the former Rājaguru of Nepal; it is not available."[17] I cannot identify this manuscript from any known catalogue.
Q	NGMPP A1122/3 = NAK 6/2397 (originally labelled as *Bṛhadyavanajātaka*) Paper manuscript. Incomplete. 81 folios (ff. 8-87, 90). 41.6 x 13.2 cm. Eleven lines per page. One binding hole. New Newarī script (Northern Nāgarī). Eighteenth century on the grounds of orthography and the red lines used for alignment. Some folios missing and damaged but in general highly legible.
P	Manuscript A.3 from Sylvain Lévi's collection, copied c. 1890, 66ff. "This manuscript was evidently copied... by a very careless scribe... There are many omissions, the largest being from chapter 22 to 53."[18] It is not available to me and its content is reported in Pingree's edition.
J	NGMPP A31/15 = NAK 1/619 (labeled as K by Pingree) Palm leaf manuscript. Incomplete. 14 folios. 43 × 5 cm. Nine lines per page. Two binding holes. Devanāgarī. Clear and legible, this manuscript was not available to Pingree. Although it was indicated on f. 108r as *Yavanajātaka* by a second hand, I have not so far identified any

[15] For other unexamined manuscripts which may be connected with our *Yavanajātaka*, see Shastri 1897: 311 and Pingree 1978a: I.35. Pingree reported also a "second *Yavanajātaka*" which "displayed some knowledge of Mīnarāja's work" but appeared to be unrelated to our *Yavanajātaka* (Pingree 1978a: I.32-35).

[16] Pingree 1978a: I.23.

[17] Ibid.

[18] Ibid.

	content of the *Yavanajātaka* in it.
L	Leipzig 1081. "11 ff. Śāradā script. This manuscript, on ff. 1v-9r, contains *Yavanajātaka* 44; 50; 48; 49; 46; 47; and 45. All the variants are indicated in the apparatus criticus. Ff. 9r-11r contain a text on *Binduphala*. L is only infrequently useful."[19] It is not available to me and its content is irrelevant to the last chapter of the work.
S	NGMPP A410/1 = NAK 4/2204 Paper manuscript. 270 folios. 22.1 × 9.6 cm. Six lines per page. No binding hole. Devanāgarī. Labeled as *Yavanajātaka* by an unknown hand on the cover. It appears to be a work known as *Jātakasāra* and does not appear to contain anything analogous to our *Yavanajātaka*.
T	NGMPP E2044/19 = E38338 Paper manuscript from a private collection in Patan. Incomplete. 16 folios (ff. 40-55). 35 × 15 cm. Twelve lines per page. No binding hole. Devanāgarī. *Yamanajā* written on left margin of the verso of all folios. Catalogued as *Yavanajātaka* when the microfilm was made in 1987. At least a part of its content corresponds to Chapter seven of Mīnarāja's *Vṛddhayavanajātaka*.
V	NGMPP E2388/4 = E44330 Paper manuscript. 34 folios. Damaged (only the right-half remains).15.5 × 4.4 cm. Six lines per page. Two binding holes (?). Old Newarī script (Northern Nāgarī). Catalogued as *Yavanajātake balavidhiḥ* and filmed in 1989. The script and even the handwriting is remarkably similar to N. The fragments cover various parts from chapter one to seventeen of the *Yavanajātaka*.

II.2 Parallel texts and Testimonia

II.2.1 Parallel texts

Some parallel materials have been identified between the *Yavanajātaka* (abbreviated as YJ henceforth) and Mīnarāja's *Vṛddhayavanajātaka* (VYJ, early fourth century?).[20] The VYJ contains seventy-one chapters in 8000 verses,[21] and is at least twice as large as the

[19] Ibid.

[20] Pingree 1959a: 268; 1978a: 24-28.

[21] "Mīnarāja, having considered with his own discernment, skilfully made the treatise of horoscopy of 100,000 [verses], which the ancient sage taught Maya, into 8,000 [verses]." *yad uktavān pūrvamunis tu śāstraṃ horām ayaṃ lakṣamitaṃ mayāya | tan mīnarājo nipuṇaṃ svabuddhyā vicintya cakre 'ṣṭasahasramātram* || VYJ 1.2. There are however only 4,357 verses in Pingree's edition (Pingree 1978a: I.24-25).

YJ.[22] Since Pingree's dating of the VYJ is partially contingent on the dating of the YJ which is now thrown into question (§III.2.1), the relation between VYJ and YJ should be re-examined.[23] A number of later works such as Kalyāṇavarman's *Sārāvalī*,[24] Govindasvāmin's *Prakaṭārthadīpika*,[25] Viṣṇuśarman's *Muhūrtadīpikā*,[26] and other minor works contain also portions of the YJ.[27] However, none of these works contain materials on mathematical astronomy such as those of the last chapter of the YJ and are therefore beyond the scope of the present study.

Beside the abovementioned works, there exist also a large number of hitherto unexamined Sanskrit horoscopic treatises which are attributed to *Yavanas* or contain part of the YJ; their relation with the YJ remains to be investigated.[28]

II.2.1 Testimonia

Beside the parallel materials of which the question of interrelation among the texts cannot be readily solved, there are two main testimonia of the YJ, both of which are relevant to the present chapter: they are, 1) Bhāskara's commentary on the *Āryabhaṭīya* (YJ 79.55, 57-58), and 2) Utpala's commentary on Varāhamihira's *Bṛhajjātaka* (YJ 79.15). The readings from these two sources sometimes diverge from N and are therefore important reference to the edition of our text which so far relies only on a scarce number of manuscripts.

The date of Bhāskara's commentary of the *Aryabhaṭīya* (629 CE) where the YJ was quoted should be taken as the upper limit for the YJ. Judging from the frequency Yavaneśvara was quoted by Utpala (966 CE) in his commentaries (over fifty times in both his commentaries on the BJ and the BS), together with the amount of parallel materials found in works such as the *Sārāvalī* of Kalyāṇavarman, one can suppose the popularity of this work up to at least the tenth century.[29]

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22 See §III.1.

23 Some preliminary comparisons between the YJ and VYJ were made in my paper "The "oldest Indo-Greek text in Sanskrit" revisited - additional new readings from the newly discovered manuscript of the *Yavanajātaka*," presented during the 60th annual conference of the Japanese Association of Indian and Buddhist Studies held in Matsue, Japan. The paper is due to be published in *Journal of the Japanese Association of Indian and Buddhist Studie*s 日本印度学仏教学会(62), 2014. In one group of parallel materials, the VYJ appears to contain core content from which the YJ expanded on. See discussion below in §III.4.2.

24 800-850 CE. Pingree 1978a: II.446.

25 c. 850 CE, commentary on Parāśara's *Horāśāstra*. Pingree 1978a: II.447.

26 Late fourteenth century, commentary on his father Vidyāmādhava's *Vidyāmādhavīya*. Pingree 1978a: II.451.

27 Pingree 1978a: I.23; II.

28 Pingree 1978a: I.23, 35-36.

29 Utpala’s commentary was dated śake 888 (966 CE) in at least one manuscript and should be accepted since

Beside the variants, another important observation on these testimonia concerns the way the YJ was cited. If the texts were transmitted correctly, in the words of Bhāskara and Utpala, Yavaneśvara was treated as an attribute to Sphujidhvaja rather than as a separate author. This gives rise to the suspicion that *Yavaneśvara* could have been just a generic epithet like *Yavanendra* or *Yavanādhirāja* found in other texts. (See discussion on the identity of Yavaneśvara and Sphujidhvaja in §III.2.2.)

III. Contents

III.1 Composition

Pingree's edition of the *Yavanajātaka* contains about 2270 verses, in contrast to the "4000 verses" stated in the colophon (v.62). It deals with various aspects of horoscope-based genethliacal astrology and is considered to be a prototype for a whole genre of such works known as *jātaka* which proliferated in the later age.[30] The purported last chapter is unique in the sense that it deals with mathematical astronomy,[31] the application of which was presumed in the casting of horoscopes to provide data such as date/time measurement and planetary longitudes, and may thus be considered as the "core of horoscopy" or the "supreme eye" of *horāvidhi* as the author of our text called it (v.1). Suchlike calculations, important as they were, however, were usually treated separately in treatises belonging to the *gaṇita* (calculation) category.[32] The content of this purported

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Utpala, as a Kashmirian astronomer of various works including the commentary on the BS, was mentioned in Alberuni's work on India dated around 1030 CE (Sachau 1888 I: 157-158, 298; Kane 1949: 22-23).

[30] This is not to be confused with the Buddhist *jātakas* which deal with the past lives of the Buddha and contain nothing of astronomical or astrological nature. The title *jātaka* to describe contents specifically dealing with *horā* appears to be a later usage when horoscopy emerged in India during the early centuries of the common era.

[31] The chapters were not numbered in the mss. and only in Q were the verses numbered. This so-called last chapter was numbered by Pingree originally as 76 (Pingree 1962: 27), was later changed to 79 in his 1978 edition. In the latter, the titles "karmārambhaḥ" and "ārambhavidhiḥ" given to chatpers 77 and 78 respectively were Pingree's conjecture. In Q, the verses of chapters 77-79 were numbered together to form what appears to be one chapter. Pingree separated this chapter out probably due to the consideration of its mathematical content.

[32] The three categories of *jyotiḥśāstra* according to Varāhamihira (sixth century CE) which later became largely standard are: i) *gaṇita* or *tantra* (mathematical astronomy); ii) *horā* or *jātaka* (genethliacal astology or horoscopy); iii) *saṃhitā* (collection of natural astrology and divinatory practices). *Bṛhatsaṃhitā* 1.9 (Tripāṭhī ed.). It may be noted that while the *Vedāṅgajyotiṣa* attributed to Lagadha contains also elements of astrological nature such as the description of the presiding deities for each *nakṣatras*, it deals with by and large mathematical astronomy and contains no element of horoscopy or even references to planetary motion other than that of the Sun and the Moon.

last chapter is remarkable also in the sense that it is amongst the oldest Sanskrit *jyotiṣa* texts extant dealing with planetary motion and civil-day computation (*ahargaṇa*), although the exact date of composition is now put into question. The topics of this chapter are summarized as follows:

Topics	**Verse(s)**
Introduction - reference to Greek source	79.1
Description of astronomical cycles (*yuga*) and Vasiṣṭha's astronomy	79.2-4
Tithis and the four types of time measurement	79.5-6
Civil days	79.7
Rising of Moon and asterisms	79.8
Solar and sidereal months	79.9
Intercalary months (*adhimāsa*)	79.10
Number of civil days in four types of months	79.11-13
Epoch of the Śaka and the Kuṣāṇa era	79.14-15
Reckoning of elapsed days (*ahargaṇa*)	79.16-20
Mean motion of Sun and elongation of Moon	79.21
True motion of Sun, Moon and stars	79.22-26
Water-clock and time measurement	79.27-29
Course of Sun, gnomon, ascendent, solar year	79.30-34
Sidereal and synodic periods of planets	79.35-36
True motions of planets	79.37-51
Lords of hours, days, seasons and years	79.52-55
Source and transmission	79.56-62

A cursory examination of the topics touched upon in this chapter reveals its very Indian nature in spite of its author attributing the work to an ultimately Greek source. Such features include the dependence on the tithis, references to the Śakas and Kuṣāṇas[33] and descriptions of Indian source and transmission of the text. The mathematics and units employed in this last chapter largely resembles generally to those of the *Vedāṅgajyotiṣa* (§III.4.1), and not to any known Greek sources.

In other chapters, one can identify at different levels elements bearing undeniably Indian characteristics, such as the twenty-eight *nakṣatras,* the Indian deities, the Sanskrit alphabet and various references to Indian society (§III.2.3.2). While Pingree tended to see all these as Sphujidhvaja's skillful Sanskritization, the varying degree of acculturation should be more carefully examined and distinguished. In the case of chapter seventy-two on Sanskrit alphabet and chapter seventy-three which deals with military astrology where

33 Spelt as *koṣāṇa-* in our text (v.15).

the twenty-eight *nakṣatras* were mentioned, the Indian elements have in fact become the core element of the chapter concerned. Concerning the last example, Pingree thus wrote, "...it is clear that much of Sphujidhvaja's material is derived not from Greek sources...." Pingree however did not explain how these counter-evidences fit into his assumption of the text being a translation from a Greek exemplar. Taking all these clues together, the work was most likely conceived originally in Sanskrit, including ideas which were nonetheless ultimately foreign in origin.

III.2 Date and Authorship

III.2.1 Dating of the YJ based on *bhūtasaṃkhyā* readings

The idea of "two names" and "two dates" given in the last three verses of the YJ was first proposed by Shastri in his report and transcription of the text dated 1897:

> "There are evidently two names and two dates. The first is Yavanēçvara, in the year Viṣṇugraha, i.e., 91 of some era not mentioned who translated into Sanskrit a work from his own language. The second is Sphūrjjidhvaja in 191 of the same era who rendered the translation into 4,000 Indravajrā verses".[34]

Shastri furthermore dismissed the possibility of Yavaneśvara and Sphūrjjidhvaja [sic] being the same person previously suggested by Kern.[35]

Shastri's reading of the text was at best preliminary and was fraught with speculation and mistakes. Besides the misreading of "Sphujidhvaja" as "Sphūrjjidhvaja",[36] his reading of the two phrases "*viṣṇugraha++++*" and "*nārāyaṇāṅkendumayādi*" turned out to be incorrect and should read instead as "*viṣṇugraha<kṣā>ṅśu++++<rāt>*" and "*nārāyaṇā<rke>ndumayādi*" respectively.[37] Shastri proceeded to interpret these phrases as the *bhūtasaṃkhyā* reading of **91** and **191**, although there were no precedents of using the words *viṣṇu* and *nārāyaṇa* to refer to the number 1. Furthermore, no words of "year" or "era" were mentioned in the verses as one would expect.

While Shastri should be credited for the discovery of this important text, his erroneous reading of the two dates "of some era not mentioned" was later adopted by Kane who conjectured the era to be Gupta in the latter's 1955 paper titled "Yavaneśvara and

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[34] Shastri 1897: 311-312.

[35] According to Shastri, this claim is not tenable because the manuscript "uses the word prāk 'formerly,' i.e. Sphūrjjidhvaja rendered into verse what was formerly translated by Yavanēçvara." (Shastri 1897: 312). Kern's remark was based on his reading of Utpala's commentary on Varāhamihira's *Bṛhajjātaka*. In retrospect, however, Utpala's interpretation as noted by Kern should be reconsidered. See discussion in III.2.2.

[36] The mistake was later corrected in his 1911 reports (Shastri 1911: 5-6).

[37] See apparatus and notes on vv. 60-62. The problem of these *bhūtasaṃkhyā* readings was first discussed in Mak 2013: 5-9.

Utpala".[38] Kane accepted Shastri's interpretation but he corrected the second name to Sphujidhvaja as he was aware of the expression "*Yavaneśvara-sphujidhvaja*" which occurred in Utapla's commentary on the *Bṛhajjātaka*.[39]

In 1958, Pingree obtained the transcript from Kane. In the footnotes of his 1959 paper titled "A Greek Linear Planetary Text in India", Pingree arrived at the conclusion that the unspecified era should be Śaka which began in 78 CE.[40] He credited this interpretation to a minor remark made by Ramaṇa-Šāstrin, who interpreted Shastri's *bhūtasaṃkhyā* date of Sphujidhvaja's composition (**191**) as 269 CE.[41] Pingree accepted this date and furthermore proposed that the date of Yavaneśvara's composition should the year Śaka **71** **(**149 CE) instead of **91**. The reason for the new reading is that Pingree read -*graha* as 7 instead of 9, on the ground that while later *bhūtasaṃkhyā* would interpret *graha* (planet) as 9, the inclusion of the pseudoplanets *Rāhu* and *Ketu* among the planets (*graha*) was "an impossibility in the second century" as suggested by the *Śārdūlakarṇāvadāna* (ŚKA).[42]

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[38] Kane 1955: 1. At the time when he wrote the paper, Kane was still in the process of acquiring a transcript of the manuscript and did not have the chance to examine the original text. After the paper was sent off to press, he received the transcript and added a supplementary note to the paper with a remark that "the manuscript in the original appears to have gaps and is incorrect in many places" (Kane 1955: 8).

[39] Kane 1949: 20-21; 1955: 1. See also earlier note on Shastri's correction in his 1911 report.

[40] Pingree 1959b: 282 fn.3.

[41] Although Ramaṇa-Šāstrin did not give an explanation why he assigned the date to the Śaka era, it appears that he was influenced by Utpala's commentary on BJ 7.9 where a date in the Śaka era was given in relation to *Yavanaeśvara-sphujidhvaja*, whom he took as a single person just like Kern did. Furthermore, he read this date provided by Utpala as 93 CE, which was interpreted as the *terminus post quem* for the composition of the *Yavanajātaka*, together with 269 CE as the *terminus ad quem* (Ramaṇa-Šāstrin 1922: 20).

[42] Pingree 1959b: 282 fn.4. Pingree's reasoning is problematic for a variety of reasons. First of all, the interpretation of one text does not necessarily entail the impossibility of an interpretation different from it in another. Secondly, for the condition to apply, Pingree had to presume the text to be dated prior to the second century, which makes his reasoning circular. Lastly, the claim that there were no Rāhu and Ketu in the second century in fact cannot be made based on the Sanskrit ŚKA and its extant Chinese translations. As reported by Mukhopadhyaya, the first Chinese translation extant, *Modengjia jing* 摩登伽經 (T1300) by Zhu Lüyan 竺律炎共 and Zhi Qian 支謙 was dated 223-253 CE (Mukhopadhyaya 1954: 53, 104, 229). However, earlier Chinese translations of the ŚKA such as the one by An Shigao 安世高 (T551, mid-second century) does not contain this passage at all and hence the dating of the Sanskrit ŚKA where the description of seven planets is found is problematic. In T1300, both seven planets and nine planets were mentioned (今當為汝復說七曜：日、月、熒惑、歲星、鎮星、太白、辰星，是名為七。羅睺、彗星，通則為九。T1300.21.405b). Thus, what we can conclude from the above is simply that the Sanskrit ŚKA as we now know is dated prior to the mid-third century CE, and that both seven planets and nine planets were known to the Chinese as early as the mid-third century CE. From the way Pingree paraphrased his argument in another article, his understanding of the Chinese materials which formed the basis of his claim appears to be faulty; the only valid support for his

By the time Pingree published his critical edition of the YJ, he had introduced some improvements as well as emendations to Shastri's original reading. "*viṣṇugraha*" became "*viṣṇugraha†kṣe*" and "*nārāyaṇāṅkendumayādi*" was emended as "*nārāyaṇāṅkendu-mitābda-*". However, upon closer scrutiny of the manuscripts, neither of the two *bhūtasaṃkhyā* dates are supported by N or Q.

The main problem with the first expression noted in N is the broken *akṣaras* which follow "*viṣṇugraha*", unreported in Shastri's transcription but indicated in Pingree's edition as a mysterious "*kṣe*" marked with an obelus.[43] Leaving aside the problem of the unattested usage of *viṣṇu* to represent 1, this extra syllable makes the *bhūtasaṃkhyā* reading unlikely if not impossible.[44] Our suspicion is confirmed by Q which read "*viṣṇugraha<kṣe>++tāvatārāt*", suggesting that the expression *viṣṇugraha* belongs to a much long compounder which indicates the mundane transmission (*avatāra*) of the text.

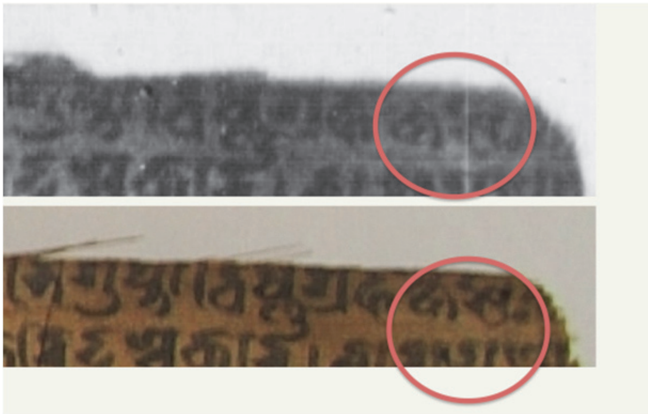

Figure 1 A fictitious *bhūtasaṃkhyā*? N103r(enlarged). N_{bw} (top), N_{c} (bottom). *viṣṇugrahakṣāṅsu...* (YJ79.60b).

Pingree's emendation *nārāyaṇāṅkendumitābda* from *nārāyaṇārkendumayādi* is similarly problematic from a textual point of view. First of all, beside the lack of precedence of the use of *bhūtasaṃkhyā* as it has already been pointed out, Pingree's transcription of this particular expression, presumably following that of Shastri's, was in fact faulty. Although the manuscript is broken at this point, based on what has remained,

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claim is "the complete absence of any other references to Rāhu or Ketu in the available portions of the *Yavanajātaka*" (Pingree 1959a: 268-269).

43 Q reads "*kṣāṅśu*", which is a possible reading for the broken *akṣara*-s in N103r1. See discussion under v.60 for different plausible emendations. I thank Harunaga Isaacson for pointing out to me the characteristic use of the ligature "ṅśu" to represent "ṃśu" in this manuscript.

44 As Falk later pointed out, such interpretation "is not required or necessary" (Falk 2007: 143 fn1). If my emendation is correct, a forced *bhūtasaṃkhyā* reading may render the combination *viṣṇu+graha+ṛkṣa-* into the impossible figure of 2771 or 2871. The strangeness of *viṣṇu* to represent 1 has been noted by others (Sarma 2009: 66).

all copies of N showed -*āṅke* to be an impossible reading. The most plausible reading should be -*ārke*, which could be read clearly in Q. Secondly, even if this turns out to be a *bhūtasaṃkhyā*, the reading *indu*(1)*arka*(12)*nārāyaṇa*(1) would generate an unlikely number of **1121**, that is, assuming the rather doubtful reading of *nārāyaṇa* as 1. These observations confirmed Falk 2007 's suspicion that "Pingree provides each of his two authors Yavaneśvara and Sphujidhvaja with a particular date, none of which may exist!".[45]

In sum, on the grounds of both manuscript evidence as well as general observation of the text, the commonly accepted dating of 149/150 CE and 269/270 CE being the date of composition of the prose and versification of the *Yavanajātaka* by Yavaneśvera and Sphujidhvaja respectively must be discarded.

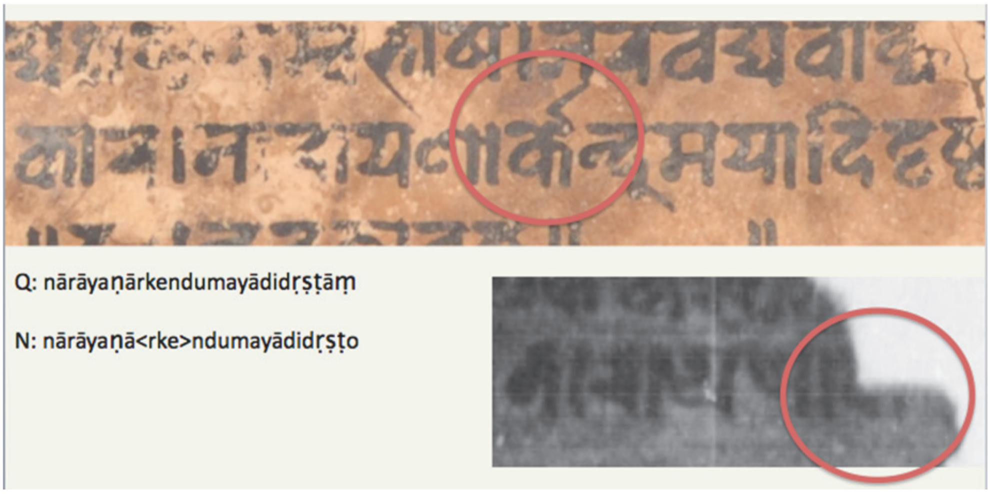

Figure 2 Another fictitious *bhūtasaṃkhyā*? Q90v (top), N_{bw}103r (bottom). Note that although N is broken off, Pingree's emendation of *nārāyaṇāṅke...* is unlikely since we would expect here a conjunct consonant *ṅke*/*ṅka* as it is customary in this script (rather than an *anusvāra* + *ke/ka*), which is impossible given what is left. Q, though dated later and may not represent what was written originally in N, provided us nonetheless a clear and simple solution.

III.2.2 Identity of Yavaneśvara and Sphujidhvaja

The identity of Yavaneśvara and Sphujidhvaja cannot be firmly established given the extant material. Yavaneśvara, literally "lord of the Greeks", appears to be a generic name to Greek authors on astral science similar to *Yavanācārya* and *Yavanādhirāja* which are attested in other texts. Sphujidhvaja, transcribed incorrectly first by Shastri as *Sphūrjjidhvaja*, appears to be a non-Sanskrit name. Kern was apparently the first to point out that Sanskritized Greek names were often subject to quasi-corrections and that Sphujidhvaja might represent Aphrodisius.[46] Later, Ramaṇa-Šāstrin suggested also

[45] Falk 2007: 143 fn2.

[46] Kern 1865: 48 fn.

Ἀφροδιτοσημαίος as the underlying form of Sphujidhvaja, which he amended to Āsphujidhvaja.[47] Pingree followed this interpretation and connected *sphuji* with *āsphujit*, which appeared in YJ 5.9 as the Sanskrit translation of Ἀφροδίτη, the Greek word for Venus.[48] The name was thus half-Greek and half-Sanskrit.

Concerning the relation between Yavaneśvara and Sphujidhvaja, as mentioned earlier (§II.2), it should be noted that historically the two names appear to be considered by some Sanskrit authors to refer to the same person. Bhāskara quoted YJ 79.55 and YJ 79.56 in his commentary on the *Āryabhaṭīya* (III.Kālakriyāpāda) v.16 and v.17 respectively.[49] In both cases, Bhāskara attributed the verses to "Sphujidhvaja-yavaneśvara" (*uktaṃ ca sphujidhvajayavaneśvareṇa*). The instrumental singular ending excludes the possibility of a *dvandva* (coordinative) reading of the compound, making a *karmadhāraya* (attributive) reading the most logical interpretation.[50] It is therefore most likely that Bhāskara understood Yavaneśvara and Sphujidhvaja to be the same person, and the inclusion of Sphujidhvaja helps to identify the particular "Lord of the Greeks" (*yavaneśvara*) among a number of them who were sometimes referred to generically in plural.

In the case of Utpala's references, three centuries later than that of Bhāskara's, it is clear that the commentator understood Sphujidhvaja and Yavaneśvara as the same person. Citations from the YJ are found throughout Utpala's commentaries on the BJ and the BS. In most cases, Utpala attributed the quotations to "Yavaneśvara";[51] three quotations were attributed to "Sphujidhvaja".[52] In Utpala's commentary on YJ 79.15, the commentator remarked that based on the description of a particular astrological configuration, "Yavaneśvara" (who was the author of our *Yavanajātaka*) should be different from the *Yavana* described by Varāhamihira in his verse (BJ 7.9).[53] He commented furthermore

47 Ramaṇa-Šāstrin 1922: 20.

48 Pingree 1978a: I.5. Pingree, however, did not seem to have acknowledged Kern's comments on the authors of the YJ, which was known to Shastri, whose view on the *bhūtasaṃkhyā* dates he followed.

49 Yano brought to my attention of these verses which Pingree apparently was not aware of, and I have discussed their importance (Mak 2013: 16). No variants were reported in Shukla's edition (Shukla 1976: 295, 298). The fact that the phrase was noted twice should make the reading quite reliable.

50 Another possibility is to interpret the noun phrase as a *bahuvrīhi* (exocentric) compound, meaning "by that (work) which (was composed by or whose authors were) Sphujidhvaja and Yavaneśvara. Though this is not entirely impossible as Sanskrit compounds often yield to such ambiguities, this convoluted derivation does not appear to be the intention of Bhāskara.

51 In total, fifty-one passages are identified in Utpala's commentary on the BJ. Out of these, forty-six were identified with Yavaneśvara, three with Sphujidhvaja and the remaining without identification. In his commentary to the BS, around fifty passages can be identified, almost all were identified with Yavaneśvara except three which were unidentified.

52 YJ 79.15, 26.12, 26.17, quoted in Utpala's commentary on BJ 7.9 and BJ 20.2.

53 *mayayavanamaṇitthaśaktipūrvair iti / na ca yavaneśvarakṛte śāstre tathāvidhe āyurdāyo dṛṣṭaḥ / yasmād*

that "another treatise was made by the Yavaneśvara Sphujidhvaja" (*yavaneśvareṇa sphujidhvajenānyac chāstraṃ kṛtam*) and Sphujidhvaja alone denoted the author of this work (*tathā ca sphujidhvajaḥ*). Though Utpala's explanation is not entirely clear on the difference between the two names, the point here is that Utpala did not take Yavaneśvara and Sphujidhvaja as two persons but one. In other words, Yavaneśvara was an epithet for Sphujidhvaja; Yavaneśvara was one of the many Indo-Greeks who propagated different versions of the Greek astral science.

The idea that *Yavaneśvara* could be an epithet for Sphujidhvaja is further supported by similar usage of *Yavanādhirāja* as the epithet for Mīnarāja in the VYJ.[54] In the case of VYJ, it would be impossible to postulate the existence of a separate *Yavanādhirāja*.

Among the modern scholars, Kern and Ramaṇa-Šāstrin held the opinion that Yavaneśvara and Sphujidhvaja referred to the same person.[55] As shown earlier in III.2.1, the treatment of the two names to refer to two unique individuals was first proposed by Shastri, who disputed Kern's interpretation, followed by Kane and Pingree. Such treatment was motivated by the *bhūtasaṃkhyā* readings of the two dates which have been shown to be untenable.

III.2.3 Idiosyncrasies and inconsistencies of the text and their implications

A number of unusual features of the YJ give us some clues with regard to how this text might have been conceived and composed. They also reveal how the text might have undergone different stages of expansion.

III.2.3.1 Greco-Babylonian elements

As explained at the beginning of the text, this last chapter is intended to be a summary of planetary science "according to the instruction of the Greeks" (v.1), we naturally expect to find predominantly Greek elements in the work. Astrological concepts such as the twelve zodiacal signs (*meṣa* etc.), the planetary days, and the technical terms for ascendent (*horā* < *ὥρα*), minute (liptā < *λεπτόν*) and in earlier chapters, decan (*drekkāṇas/drekāṇas/drekkas/drekas* < *δεκανός*), must be connected to their Greek

yavaneśvareṇoktam / āyūṃṣi rāśyaṃśarāśiyogāt iti / atrocyate / yavaneśvareṇa sphujidhvajenānyacchāstraṃ kṛtam / tathā ca sphujidhvajaḥ / gatena sābhyardhaśatena yuktā 'py aṅkena keṣāṃ na gatābdasaṃkhyā / kālaḥ śakā-1044-nāṃ sa viśodhya tasmād atītavarṣād yugavarṣajātam // evaṃ sphujidhvajakṛtaṃ śakakālasyārvāg jñāyate / anyac ca yavanācāryaiḥ pūrvaiḥ kṛtam iti tadarthaṃ sphujidhvajo 'py āha / yavanā ucuḥ / ye saṃgrahe digjanajātibhedāḥ proktāḥ purāṇaiḥ kramaśo grahasya / tad etaj jñāyate yathā varāhamihireṇa pūrvayavanācāryamatam evopanyastam asmābhis tan na dṛṣṭam / sphujidhvajakṛtam eva dṛṣṭvā parāśarasyāpīyam eva vārtā / (Jha ed. p. 143).

[54] *prāg brāhmaṇā proktam anekarūpaṃ yac chākunaṃ pūrvajakarmasākṣam | tan mīnarājo yavanādhirājaḥ samāsataḥ sārataraṃ cakāra* || VYJ 67.1.

[55] Kern 1865: 48 fn, 51; Ramaṇa-Šāstrin 1922: 20.

antecedents given their blatant resemblance and the lack of parallel concepts in the Vedic corpus.[56]

From the astronomical side, however, not all contents found in the YJ can be identified with any Greek astronomical theories known to us, for example the *yuga* of 165 years and the emphasis on the use of the unit *tithi* - both are key elements of the YJ. The description of four types of months and the reckoning of elapsed days (*ahargaṇa*) which make up a large portion of our text were typical of all later Hindu astronomical systems and were not known in Greece or Babylonia as far as extant textual or archeological materials are concerned.

Pingree identified two bodies of materials in YJ which seemed to carry certain resemblance to Greco-Babylonian astronomy, namely, 1) the linear zigzag function for the rising times of the zodiacal signs (v.26), and 2) the planetary theory (v.35-51). In the first case, Pingree provided two interpretations to v.26 and attributed one interpretation to a certain "Greek adaptation of the Babylonian System A".[57] This interpretation, however, requires a reading of thirty-six muhūrtas in a nychthemeron, which is impossible because the text clearly stated that there are thirty muhūrtas in one day (v.29) as it is normal in India.[58] For the second case, Pingree connected the planetary theory of the YJ to "a Greek adaptation of Babylonian planetary theory of the Seleucid period", which is characterized by establishing the synodic period of each planet and the intervals in degree between the occurrences of the so-called "Greek-letter phenomena".[59] A detailed comparison is required to establish the extent the work is indebted to its "Babylonian origin".

Elsewhere, the algorithms and data presented in the YJ appear to share some superficial similarities with Indian astronomical works such as the VJ (day-night ratio at solstice, namely 3:2/2:3, v.31) and *Pauliśasiddhānta* of the PS (elongation between each planet and the Sun, v.50). However, such comparison is not conclusive unless we know more about the origin and textual history of the materials compared to, which are unfortunately deficient at present.

The description of an outflow water-clock (v.27) is most likely ultimately of Babylonian origin.[60] However, since similar features of a water-clock were described also in the VJ and the *Arthaśāstra* (AŚ), we are not of absolute certainty whether the text took the materials directly from some Greco-Babylonian source, or incorporated the

[56] For general discussion on Greek loanwords in Sanskrit, see Burrow 1955: 387-388; for specific discussion on astronomical loanwords, see Yano 1987.

[57] Pingree 1978b: 539.

[58] For discussion on the normal reading and Pingree's alternative interpretation, see notes on v.26. Strangely, Pingree in his 1978b analysis presented only this alternative interpretation but not the standard one (ibid., Table III.4).

[59] Pingree 1978b: 540.

[60] See discussion below (§III.2.3.2) and also notes to v.27.

Indianized form of knowledge which was certainly available to Sphujidhvaja. In fact, if Sphujidhvaja could refer to other Indian astronomical author (v.3) and applied Indian concepts such as *tithi* throughout his work (v.6, *passim*), there is no reason to doubt that other apparently Greco-Babylonian materials could also have been simply adapted from some Sanskrit sources which contained them.

In sum, while the text bears some unmistakably Greco-Babylonian elements, we cannot ascertain how much they had been altered as they were adapted to the language of Sanskrit astral science. The text itself does not reveal how much and which materials of the texts are from the Greeks, the Indians or Sphujidhvaja himself. Materials such as the *yuga* of 165 years which cannot be traced to any known Greek or Indian astronomical systems might represent an earlier but lost tradition in Greece, India or anywhere else.

III.2.3.2 Indian elements

The non-Greek, Indian elements in the YJ as mentioned earlier (§III.1) may be identified and further examined at different levels. At a larger level, certain chapters are found to be of undeniably Indian origin, namely, chapter 73 on *yātrā* (military astrology) based on Indian *nakṣatras* and chapters 71 and 72 on naming using Indian alphabet or *akṣaras*.[61] At a minor level, Indian elements such as reference to Indian deities, castes, Āyurveda and even the *kāpālikas*, the Śaiva mendicants, are found throughout the text. Some of these highly idiosyncratic elements appear to be an integral part of the text and the astrological system presented therein and should therefore be considered original in the sense that they were not just mechanically inserted into the text replacing some presumably "original" Greek elements.

Beside the striking resemblance between the YJ and other known Indian astronomical texts on the topics of the water-clock, the *tithi*-based astronomical calculation and the concept of *yuga* as described earlier, the way Indian elements were utilized in the text may be best illustrated by the units employed therein. The specification of a gold needle used in describing the hole of a water-clock (v.27) with the equal ratio of *māṣaka* for weight and *aṅgula* for length is practically same that of the AŚ and is not known in any other Greek or even Sanskrit sources. Elsewhere, the Indian units of the YJ such as *nimeṣa*, *kalā*, *pala*, *kuḍava* and *nāḍikā* (v.28) are known in Indian texts of the early common era, although this particular combination is not attested anywhere, suggesting the mixed nature of the sources of the YJ (§III.4.1),

III.2.3.3 Mathematical astronomy as the last chapter of an astrological work

While the mixture of Greek and Indian elements in this chapter in a way conforms with the overall amalgamated style of the work, the structure of an astrological work appended with a mathematical chapter at the end is rather rare and has so far not been attested

[61] Since these chapters are found only toward the later portion of the work, there is a possibility that they are later additions, although the consistency of style does not appear to support this possibility.

elsewhere.[62] Judging from the way materials from this chapter were quoted by Bhāskara and Utpala, we will nonetheless have to say that the work was transmitted as such, that is, together with this mathematical chapter at least from the seventh century on, and most likely much earlier.

Although the mathematical nature of this last chapter of the YJ seems to set itself apart from the rest of the text, some degree of textual coherence is shown by the fact that one verse (v.26) mirrors closely an earlier verse in the first chapter (1.68).[63] On the other hand, the wrong description of the text as "four thousand verses in *indravajrā* meter" (v.62) is difficult to justify. The text as we have it contains only about 2270 verses in *upajāti*, not *indravajrā* meter.[64] Furthermore, if our reconstruction of the verses are correct, the lines of transmission given in v.60 and v.62 overlap with each other and thus appear to redundant. As a result, v.62 appears to be an addition from a text-critical point of view.[65]

III.3 The astronomical algorithms of the *Yavanajātaka*

Some of the key algorithms stated in this chapter based on our new reading may be summarized as follows:[66]

Beginning of the epoch of luni-solar *yuga*: **21 March 22 CE** (vv.4/14)

With the understanding that,

Omitted *tithis* (*avama*) = *tithis* - civil days [I] (v.5)

Rising of asterism = civil days + Sun's revolution [II] (v.8)

Intercalary month (*adhimāsa*) = synodic months - solar months [III] (v.10)

In one luni-solar *yuga* of 165 solar years, there are: (v.3)

= 61,230 *tithis* (v.6)

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[62] One notable exception is the *Xiuyao jing* (T1299), a compendium on Indian astral science written in Chinese and attributed to Amoghavajra (705-774). See notes on v.1.

[63] There are some features of the last chapters which create some doubts about the constitution of the text as we have it. The chapter begins with first person narration (*vakṣye*) but ends in third person (*sphujidhvajo nāma babhūva rāja ya indravajrābhir idaṃ cakāra*). The inconsistency of person is however by no means unique in Sanskrit literature.

[64] In both mss. N and Q, there was a final remark "*upendravajrāvṛtta*" which appears to be a remark from a scribe who noticed the mistake. However, *upendravajrā* is not correct either.

[65] As far as the contents are concerned, this interpretation appears unlikely given the use of *prāk* in v.61d and the unique description of the source in vv. 60-61 in contrast to v.62 (Shastri 1897: 312).

[66] Cf. Pingree 1978a: I.538-540; Shukla 1989: 223. The parts which differed from Pingree's are underlined. As for the *ahargaṇa* and calculation of planetary longitudes, the author's readings agree with Pingree 1978a's data which shall not be repeated here.

= 61,230 - 958 (omitted *tithis* or *avama*) [I] = **60,272 civil days** (v.7)
= 58,231 risings of the Moon (v.8)
= 60,272 + 165 [II] = 60,437 risings of asterism (v.8)
= 1,980 solar months (v.9)
= 1,980 + 61 [III] = 2,041 synodic months (v.9)
= **2,206 sidereal months** (synodic months + Sun's revolution) (v.9)

From the above figures, the following time measurements may be derived:
1 solar (sidereal) year = **$365\frac{47}{165}$ days ≒365.28485 days** (v.34)
1 synodic month = **$29\frac{1083}{2041}$ days ≒ 29.53062 days**
1 sidereal month = **$27\frac{355}{1103}$ days ≒ 27.32185 days**
1 solar month = **$30\frac{872}{1980}$ days ≒ 30.44040 days**

Other relations given in the text:
1 tithi = 63/64 civil days (v.5)
1 civil day = ***64/63 tithi*** (v.5)
1 civil day = 30 *muhūrtas* (*m*) (v.7)
1 *kuḍava* = 3⅛ *palas* (v.28)
1 *nādikā* = 60 *liptās* = 61 *kuḍavas* (v.28)
1 civil day = 60 *nādikā* (v.28)
1 *kalā* = 790 nimeṣas (v.29)
1 *nādikā* = **10 kalās** (*k*) (v.29)
1 *muhūrta* = 2 *nāḍikās* (v.29)
1 civil month = 30 days (v.11)
1 solar month = 30 days, 13 *m*, $(4 + \frac{8}{33})$ *k* = **$30\frac{872}{1980}$ days**
(v.11)
1 synodic month = 29 days, 16 *m,* $(- 2 + \frac{762}{2041})$ *k* = **$29\frac{1083}{2041}$ days** (v.12)
1 sidereal month = 27 days, 9½ *m*, $(3 + \frac{121}{1103})$ *k* = **$27\frac{355}{1103}$ days** (v.13)

If our reading and emendations are correct, the algorithms and the figures given in this text are by and large internally consistent. The fraction 64/63 which expresses the relation between a tithi and a civil day in v.5 is only approximate, as the more precise figure may be obtained by the number of tithis in a *yuga* divided by the number of civil days in a *yuga*, i.e., 61230/60272.[67] The figures for the number of days in different kinds of months given in vv. 11-13 agree largely with our calculation based on the algorithms presented in the preceding verses. Although some emendation is necessary,[68] the rather cumbersome fractional expressions in vv.11-13 reflect most likely Sphujidhvaja's method

[67] The large denominator and numerator of a fraction may be reduced by continuously breaking the fraction into smaller fractions until a fraction is deemed small enough to be ignored. See notes to v.5.

[68] See Shukla 1989: 217-220 and my notes to vv.11-13.

of calculation, namely, by dividing the number of civil days in a *yuga* by the number of different kinds of month in a *yuga*. In his analyses of the above set of algorithms and data, Pingree suggested inconsistencies and mistakes on the part of Sphujidhvaja and criticized Sphujidhvaja's "not so exact" use of Sanskrit and his "extreme clumsiness" in his expressions of numbers.[69] Pingree's analyses of the *yuga* and the calculation of the length of year and different kinds of months were in fact incorrect mainly due to two mistakes he made: 1) wrong reading of the number of civil days in a *yuga* in v.7; 2) wrong reading of the conversion between *nāḍikā* and *kalā* in v.29. Both wrong readings were the results of unnecessary emendation. The calculation of the year using these wrong readings led him to arrive at the wrong year of 6,5;14,32 days.[70] Equally wrong was his reading of number of civil days in a solar year provided in fact in v.34 of the text. His reading of 6,5;14,47 days which he associated with the tropical year of Hipparchus (which is "only 0;0,1 day less) was the result of his own emendation;[71] the figure given in the verse, $365\frac{47}{165}$ is in fact correct and agrees with the rest of the algorithms and figures. Once again, as in most cases, correct readings may be obtained by reverting to the original manuscript readings, and in some cases, with minor emendations.

III.4 The historical position of the astronomy of the *Yavanajātaka*

The astronomy and mathematics presented in this text lack the sophistication of later *jyotiṣa* works such as those of Āryabhaṭa, and even the earlier *siddhāntas* such as those described in Varāhamihira's PS. However, a comparison of the astronomical data and algorithms of the YJ with other *siddhānta* works shows that the lengths of the solar year, the synodic month and the sidereal month are comparable to the *Saurasiddhānta* and *Romakasiddhānta* described in the PS, and are far more advanced than those adopted in the VJ. While it is tempting to date the YJ prior to the *siddhāntas* described in the PS on the ground of its smaller *yuga* (165 years) which may account for its inaccuracy of the length of the solar year, the lengths of the synodic and sidereal month are remarkably accurate.

[69] Pingree 1978a: I.23, II.406.

[70] Pingree 1978b: 538.

[71] Pingree 1978a: I.500, II.410.

	YJ	VJ	*Saurasiddhānta*[72]	*Romakasiddhānta*[73]	Modern
Yuga (years)	165	5	180000	2850	-
Solar (sidereal) year	365.2848 *d*	366 *d*	365.2588 *d*	365.2467 *d* [74]	365.2564 *d*
Synodic month	29.5306 *d*	29.5161 *d*	29.5306 *d*	29.5306	29.5306 *d*
Sidereal month	27.3218 *d*	27.3134 *d*	27.3217 *d*	27.3216	27.3217 *d*

The absence of elaboration on mathematical astronomy may be simply due to the fact that the YJ was a practical piece of work subservient to horoscopy rather than an independent work of the *gaṇita* category, and thus lacked the mathematical rigor expected from works such as those in the *Pañcasiddhāntikā*. The YJ nonetheless reflected a certain school of astronomy practiced by the Indianized Greeks who had copiously adopted Indian concepts and even the Sanskrit language itself. The Indian elements in the YJ are quite evident including specific reference to Indian works such as that of Vasiṣṭha.[75] Not so clear are links between the Greco-Babylonian elements with the prototypes which in many cases have not yet been identified and were assumed to be lost. Pingree's attempt to associate astronomical algorithm to those of the Greeks, as he did for the length of tropical year in the YJ to that of Hipparchus was shown to be faulty. There are no reasons to believe that Sphujidhvaja was obliged to be a faithful translator; in the process of amalgamating Greek and Indian astral science and thus confronted by a variety of data from difference sources, the author of the YJ could very well take the opportunity to choose or even improve on the astronomical algorithm as he saw fit, resulting in figures such as the *yuga* of 165 years and various astronomical constants that have no preceding or subsequent parallels in any of the major astornomical texts that we know, in Greek or in Sanskrit.[76]

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[72] Neugebauer & Pingree 1970-71: I.31, II.11; Sastry 1993: 16.

[73] Ibid.

[74] As Neugebauer and Pingree had pointed out, the value is comparable to Hipparchus' tropical year. The method of calculation is nonetheless same as that of the solar (sidereal) year based on the *yuga* system.

[75] See notes to v.3 for possible connection between the YJ and *Vasiṣṭhasamāsasiddhānta* of the PS. Nonetheless, it has been shown that there is not only one work of Vasiṣṭha (Kern 1865: 46-47).

[76] The remarkable progressiveness of the Indian astronomers has been noted by some (Kern 1865: 50). In some instances, aspects of older traditions were preserved resulting in repetitive layers of knowledge. Pingree, thus, took the view that "[Indian astronomers] did not usually attempt innovations in theory" (Pingree 1978b: 533) and that "the basic traditions of Indian astronomy imposed on the [foreign] external systems its particular stamp, and transformed the science of Mesopotamia, Greece, or Iran into something unique in India (Pingree 1981: 9)

III.4.1 System(s) of time units in the *Yavanajātaka*

The unique conversion 3⅛ *palas* = 1 *kuḍava*; 61 *kuḍavas* = 1 *nāḍika* stated in v.28 is found also in the VJ. The relation between *nāḍikā* and *kalā* in our text is not entirely consistent, although the conversion 1 *nāḍikā* = 10 *kalās* (v.29) appears to be predominant as it is generally assumed in other verses where *kalā* is used. This particular conversion is found in also the *Parāśara*, and is remarkably close to the one in the VJ.[77] A comparison of values in texts where units such as *nāḍikā* and *kalā* are found is as follows:

Conversion	YJ	PA[78]	VJ	MS[79]	VDP[80]	DA/ŚKA[81]	AŚ[82]
1 day = x mu	30	**30**	**30**	**30**	**30**	**30**	**30**
1 day = x nā	**60**	60	**60**	-	**60**	60	60
1 mu = x nā	**2**	**2**	**2**	-	2	**2**	**2**
1 mu = x ka	20	20	$20\frac{1}{10}$	**30**	-	**60**	80
1 nā = x ka	**10**	**10**	$\mathbf{10\frac{1}{20}}$	-	-	**30**	**40**
1 nā = x li	**60**		-	-	**60**	-	-
1 nā = x ku	**61**		61 [83]	-	-	-	-
1 ku = x pa	**3⅛**		3⅛	-	-	-	-

mu = *muhūrta*, nā = *nāḍikā*, ka = *kalā*, li = *liptā*, ku = *kuḍava* (*kuṭapa*/*kuṭumbha* in VJ), pa = *pala*

Bold indicates conversion given in the text; normal indicates conversion by calculation.

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[77] Noted first by Shukla. See notes on vv. 28/29 for discussion.

[78] *Parāśara-tantra* as quoted by Utpala in his commentary to BS 2.3. On Parāśara, see Kern 1865: 31-33. See also notes on vv. 28/29.

[79] *Manusmṛti* 1.64. The conversion is generally adopted in some *Purāṇas* as well, for example, *Viṣṇupurāṇa* (1.3.8-10ab) and *Vāyupurāṇa* (57.6-7).

[80] *Viṣṇudharmottarapurāṇa* 1.73.1-4ab. Instead of *liptā*, *vināḍikā* is used, which is the case of also *Āryabhaṭīya* and most later astronomical texts as far as time unit is concerned.

[81] *Divyāvadāna* (Vaidya ed.) p. 337 ln. 25, also ŚKA (Mukhopadhyaya ed.) p. 57 ln. 8. The *ekatriṃśad* in the manuscript reading *kalānām ekatriṃśad ekā nālikā* in Cowell and Neil's edition (p. 644 ln. 21; cited in Fleet 1915: 218) should be emended to *triṃśad*, as Mukhopadhyaya did in the parallel passage in the ŚKA. This is because elsewhere in the same passage it is given that *ṣaṣṭiḥ kalā eko muhūrtaḥ*; together with *dve nāḍike eko muhūrtaḥ*, the conversion of 1 *nālikā* = 30 *kalās* may be obtained. The Chinese and Tibetan translations also support the emendation as Mukhopadhyaya duly noted (p.57 fn. 15).

[82] *Arthaśāstra* 2.20.28-38 (vd. trans. in Olivelle 2013: 146).

[83] VJ(R) 7, 17, VJ(Y) 24. The conversion is not explicitly stated but can be deduced from the conversion of units provided by the three verses, arriving at 183 *prasthas* = 732 *kuṭapas* = 12 *nāḍikas* (Shamasastry 1936: 24-25). Technically speaking, *pala* and *kuḍava* are measures of volume and can only be converted to time unit such as the *nāḍikā* with a specific kind of water clock.

As the VJ continued to be transmitted throughout the medieval period, the primitiveness of the YJ prove neither its antiquity nor affiliation with the VJ. Nonetheless, since these Indian elements were clearly incorporated into the YJ, they must have been prevalent and readily available at its time of composition. Together with the curious features such as the absence of *bhūtasaṃkhyā* (§III.2.1) and the use of similar time units which are shared by the VJ and the YJ as we have just shown here, we can say that the last chapter of the YJ demonstrate a process of amalgamation of Greco-Babylonian and native Indian astral sciences which was prevalent during the composition of the YJ. The inclusion of *liptā* (v.28) in the conversion of units was another illustration of Sphujidhvaja's attempt to combine Greco-Babylonian and Indian traditions.

IV. Conclusion

Drawing from our observations above, a somewhat different picture of the *Yavanajātaka* begins to emerge. In the first place, the text is not as corrupt and clumsily composed as Pingree suggested, which other scholars such as Shukla and Falk have already pointed out. The conventional use of terminology, expressions and even time-measures suggests that the last chapter of the *Yavanajātaka* belongs to the same tradition of mathematical astronomy as all other extant Sanskrit texts in the early centuries of the common era, preceded possibly by the *Vedāṅgajyotiṣa* attributed to Lagadha and other lost works such as those of *Vasiṣṭha* and others mentioned in Varāhamihira's *Pañcasiddhāntikā*. The work appeared to be accepted by Indian astronomers up to the tenth century as an authoritative *jyotiṣa* text and was first quoted by Bhāskara in 629 CE which should be taken as the *terminus ante quem* of the work. We have shown that the early evidences for the use of zero in a place-holder system and the *bhūtasaṃkhyā* Pingree identified in the *Yavanajātaka* have no basis at all. While this does not mean to deny the claim of the discovery of zero as number in India, evidences for such mathematical innovation must be sought elsewhere as some scholars have attempted.[84]

[84] See Staal 2010. Staal began his essay by claiming that the evidence in support of the belief that zero originated in Indic Civilization "is almost zero", but appeared to have accepted Pingree's claim of the earliest evidence of decimal place-value system with a symbol for zero and its dating, which were referred to also in 1978 by Ruegg in his discussion of the history of the term *śūnya* (cited in Staal 2010: 5-6). Regardless of whether Staal was aware of the unreliability of Pingree's assertion, one can say that he was more interested in earlier evidences in what he called "beyond writing" and the "prehistory of zero" (Staal 2010: 6, 14ff). Some of the earliest “mathematical” references to the Indian zero are found in Varāhamihira’s *Pañcasiddhāntikā* (sixth century) where the word *bindu* was used as a *bhūtasaṃkhyā* for zero (PS 3.7) and zero was treated as an object of mathematical operations (PS 3.17, passim). The earliest physical evidences we have so far for the use of zero as well as *bhūtasaṃkhyā* are to be found somewhat surprisingly in the inscriptions of the Indianized kingdoms in Southeast Asia in late sixth and seventh centuries, the first of which is a Khmer stele K.151 dated *śaka* 520 or 598 CE (Billard & Eade 2008: 398; for general discussion and other slightly later but

The chronology of the *Yavanajātaka* developed by Pingree, following the ideas initially proposed by Shastri and Kane, is not tenable; his view that the Indian elements in the work reflect Sphujidhvaja's effort of Hinduization, as well as that the "Greek original from Alexandria" which formed the basis of the *Yavanajātaka* belonged to a lost school of Greek astronomy are at best conjectural. While some astrological and astronomical concepts described in both the last chapter and the preceding seventy-eight chapters of the work are ultimately of Greek origin, indigenous concepts such as *karma*, *Āyurveda* and references to Hindu deities found throughout the text, as well as elements not attested any extant Greek sources such as the *yuga* of 165 years and the ubiquitous unit of *tithi* which played a central role in the algorithms presented in this last chapter should be taken into due consideration. Given the considerable amount of parallel materials identified in other Sanskrit *jyotiṣa* texts such as *Vedāṅgajyotiṣa* as well as non-*jyotiṣa* texts such as the AŚ, the questions of where the contents of this last chapter of the *Yavanajātaka* ultimately comes from and how much of it owed to the Greeks remain open and there is no evidence that the *Yavanajātaka* was a translation from a Greek exemplar.

With the evidences we have seen so far, the text Sphujidhvaja composed appears to be original, based on an indigenous tradition where elements of Greek and Indian astral sciences were thoroughly amalgamated. In that respect, the *Yavanajātaka* is not so different from other works of Greco-Indian *jyotiṣa* of the early centuries of the common era. Furthermore, Yavaneśvara should be considered an epithet to Sphujidhvaja and not a seperate author of another text or translation.

nonetheless significant references, see Cœdès 1931: 328; Datta & Singh 1935: 60; Diller 1995: 68, 1996: 125-6; Salomon 1998: 61-63).

Chapter 79 of the *Yavanajātaka*

Abbreviations and symbols

Apparatus

ac	*ante correctionem* = before correction
Bh	Bhāskara's commentary on *Āryabhaṭīya* (kālakriyāpāda). Shukla 1976 edition.
N	NGMPP A31/16 = NAK 1/1180
N_t	Tucci's black-and-white photos of N.
N_{bw}	NGMPP black-and-white microfilm of N.
N_c	NGMPP color photos of N.
N_p	Pingree's reading of N (~~N~~$_p$ = reading unsupported by manuscript reading)
N_s	Shastri(1897)'s reading/emendation of N
K	Copy of N made for P.V. Kane.
P	MS. A.3 of the collection of Sylvain Lévi, copied c. 1890.
pc	*post correctionem* = after correction
p_{ed}	Pingree's emendation 1978
Q	NGMPP A1122/3 = NAK 6/2397
U	Utpala's commentary on the *Bṛhajjātaka*
s_{ed}	Shukla's emendation 1989
…	illegible/unclear
<…>	reconstruction from unclear reading
†…†	obelus: problematic/uncertain reading
+	one missing or undecipherable *akṣara*
-	lacuna
?	illegible part of an *akṣara*
=	same as: normalized from irregular *sandhi*

Translations

M	Mak's translation
P	Pingree's (1978a) translation of the *Yavanajātaka*

For other abbreviations used in the notes, see "Abbreviations of Texts" before the Bibliography.

Editorial remarks

Manuscripts:

Both manuscripts N and Q have a number of orthographical idiosyncrasies which are standardized without indication, following conventional Sanskrit orthographical/sandhi practice (ms. form → standard Romanized form). It should be noted that these phenomena are by no mean consistent even within a single manuscript.

- Nasals: 1) Anusvāra representing homorganic assimilation (*ṃ* + *g* → *ṅg*; *ṃ* + *c* → *ñc*; *ṃ* + *j* → *ñj*; *ṃ* + *t* → *nt*; …; *ṃ* + *b* → *mb*; *ṃ* + *m* → *mm*), both word-internal (e.g. *paṃca* → *pañca*) and word-external; 2) Homorganic assimilation conventionally represented by anusvāras following sandhi convention, i.e. reverse of 1) (*ṅg* → *ṃ* + *g*, etc.); 3) Sentence-ending anusvāra / anusvāra followed by vowels (*ṃ* → *m*); 4) Other non-standard representations of nasals (*mv* → *ṃ* + *v*; *ṅś* → *ṃ* + *ś*; *ṅs* → *ṃ* + *s*).
- Visarga: Assimilation before palatals (noted in N): *ś* → *ḥ*
- Gemination: 1) Internal post-rhotic (*muhūrtta* → *muhūrta*, *arddha* → *ardha*, *vargga* → *varga*); 2) Internal pre-rhotic (*tattra* → *tatra*) External post-rhotic (*rlla* → *r* + *la*); Conventional (*cch* → *ch*)
- Wrong sibilants are corrected without indication unless the variant is deemed significant. In particular, the confusion between *ś* and *s* is common in N (*śapta* → *sapta*, *seṣa* → *śeṣa*, *parisodhya* → *pariśodhya*, *dasa* → *daśa*, *kramaso* → *kramaśo*, etc.).
- Dental/retroflex confusion (noted in N): *n* → *ṇ* (*pramāna* → *pramāṇa*); *ṇ* → *n* (*sāvaṇa* → *sāvana*).

Apparatus/Translations/Notes:

- Emenedations unless otherwise indicated are mine.
- Variants after the adopted reading is generally arranged in the order of manuscript (by reliability N/Q, P/K), citation, emendation and others (misreading, etc.).
- Pingree's reading follows that of N (in f.102, K/P, whichever adopted) unless otherwise indicated (p_{ed}).
- Pingree's translations are taken from Pingree 1978a: 186-191. *Italics* for Sanskrit terms mine.

Planetary movement according to the Greeks

N100r5

sarvasya <horā>vidhisaṃgrahasya cakṣuḥ paraṃ yad vibudhā vadanti |
samāsatas tad yavanopadeśād vakṣye 'tha dṛṣṭaṃ[A] caritaṃ grahāṇām ||1||

[A] thadṛṣṭaṃ]N, pradṛṣṭaṃ ~~N~~$_p$

P: The wise say that the observed course of the planets is the supreme eye of the entire body of the rules of horoscopy. I shall explain it concisely according to the instruction of the Greeks.

Note: As mentioned in §III.1, the inclusion of a mathematical chapter in a *jyotiṣa* work of the *horā*/*jātaka* genre is unusual. In the case of Greek and Roman astral science, although both horoscopy and calculation of planetary motion may be subsumed under the broad category of *astronomia*, as early as the time of Ptolemy, the two were treated separately.[85]

As indicated by the word *samāsatas*, the chapter was intended to be a summary and gave only a minimal amount of details on planetary motion requored to cast a horoscope. Pingree was of the opinion that the computation of the planetary longitudes is not possible with this chapter as we have it.[86] However, the author's intention as well as his awareness of the importance of such knowledge are clear. It seems rather ironic that if this chapter were to fail to provide the calculation needed for the casting of a horoscope as Pingree had claimed, the author would not have praised so highly the content of this chapter as to describe it as the "supreme eye" of horoscopy and that the sophisticated design and rules described in all the earlier chapters would have all been in vain.[87]

Big versus small *yuga*

N100r5-100v1

yugaṃ mahat kecid uśanti sauraṃ sūkṣmaṃ ca[A] tadvad grahaṇārtham ādyāḥ |
tadāgamād bodhamitiprabhedād dṛṣṭeṣu gatyāsa[B] samāsabuddhiḥ ||2||

[A] sūkṣmaṃ ca]p_{ed}, sūkṣmārtha N [B] gatyāsa]emend., duṣṭa<ṣugatyāsa> N,

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[85] The *Tetrabiblos* described itself as "prognostication through astronomy" (*Τὸ δι᾽ ἀστρονομίας προγνωστικόν*), made references to the *Almagest*.

[86] Pingree 1978b: 540.

[87] This is not to say that planetary longitutde might not be obtained elsewhere. As later astrologers did, they might have obtained the data from other simplified ephemerides and even from observation. The only operation which absolutely requires calculation is the *ahargaṇa* and the reckoning of weekdays, which are described also in this chapter. One example of such combination of a summarized mathematical chapter appended to an astrological treatise is found in Amoghavajra's astral compendium *Xiuyao jing* 宿曜經 (T 1299) of the mid-eighth century CE. Although the horoscopy described therein was in a greatly abridged form, a chapter on the *ahargaṇa* and the reckoning of weekdays was similarly appended to work as noted in the Japanese manuscripts (Yano 1986: 113-129; Yano & Hayashi 2012: 22-27).

duṣṭaṣu sa vyāsa ~~N~~$_p$, dṛṣṭeṣu sa vyāsa p_{ed}

M: Some predecessors say that there is a great solar *yuga*, and also a small one for the sake of (predicting) eclipses. By such teaching through distinction by knowledge (*bodhi-*) and measure (*miti-*), there was the concise understanding of the motion (*gati*) of the observed [planets].

P: Some authorities say that there is a great solar *yuga*, and a small one for the sake of (predicting) eclipses; he who understands conciseness and diffuseness, because of the variety in visible (phenomena, thinks) that one must learn by studying these (*yuga*-s).

Note: This verse describes the difference between the solar *yuga* for calculating planetary position and a smaller one which is used for eclipse prediction. While the smaller (*sūkṣma*) *yuga* is likely to refer to the well-known 18 year eclipse-cycle, what the great solar *yuga* was referring to is uncertain. Pingree suggested this to be the *mahāyuga* of 4,320,000 years and commented that such *mahāyuga* is "certainly known in India by the second century A.D."[88] Recent studies of the development of Indian cosmic cycle suggest that the *mahāyuga* of classical Hinduism was firmly established and widely accepted only by the beginning of the fifth century.[89] In mathematical astronomy, there were other large *yuga*-s such as those of the *Saurasiddhānta* (180,000 solar years) and the *Romakasiddhānta* (2,850 solar years), both described in Varāhamihira's *Pañcasiddhāntikā*.[90] It should be noted that the astronomical *yuga*-s such as these, as well as the well-known five-years *yuga* of VJ were devised initially to reconcile the revolutions of the Sun and the Moon together with the intercalary months in whole number. The *mahāyuga* on the other hand, as far as the extent textual materials can tell, were initially undefined, and evolved later with a mythological assumption of a set of degenerative smaller *yuga*-s (4:3:2:1). Only at the latest stage were planetary motions incorporated into such system.

Since the *mahat sauram yugam* in this verse is supposed to have carried specific function of calculating planetary motion, a feature only of the later *mahāyuga* model, if it did refer to the *mahāyuga* at all, the date would be somewhat later than Pingree suggested. At any rate, the interest in large cycles was most likely the result of contact with non-native materials. The VJ which represents the most orthodox Vedic astronomical

88 Pingree 1963: 238.

89 González-Reimann 2009: 415-419. There exist various interpretations of the *mahāyuga/caturyuga* theory expressed in texts such as the *Yugapurāṇa*, *Mahābhārata* (3.186.17-23; 12.224.19-20) and *Manusmṛti* (1.68-83), suggesting that such concept had undergone a process of transformation from the third century BCE to the early centuries of the common era as the "result of an amalgamation of local traditions with external influences".

90 Sastry & Sarma 1984: 16-17.

view, with redactions as late as possibly the fifth century, showed no awareness of the *mahāyuga* and remained uninfluenced by it. The AŚ dated to the early centuries of the common era, as well as the *Paitāmasiddhānta* summarized in the PS too defined the *yuga* as five years as their Vedic predecessors did. *Siddhāntas* such as *Romaka* and *Saura* (both in the PS) utilized *yugas* of 2850 and 180,000 years respectively. The increase of *yuga* is a natural development as the astronomers attempted to reach more accurate figures for their astronomical algorithms.

Vasiṣṭha's astronomy and the Greek luni-solar *yuga*

N100v1

muner vasiṣṭhasya[A] matānuvṛttyā keṣāṃ cid iṣṭaṃ vidhitatparāṇām[B] |
<yugo ravīndvor>[C] yavanottamānāṃ ṣaṣṭiḥ[D] śataṃ pañcayutaṃ samānām ||3||

[A] vasiṣṭhasya]emend., vaśiṣṭha N_{ac}, vaśiṣṭhasya N_{pc}, vaśiṣṭha<sya> N_p

[B] °ṃcidiṣṭaṃvi°]~~N_p~~ (emend.), °mvidiṣṭamvi° N [C] yugo ravīndvor]emend., y?+r?vidvor N, - N_p

[D] ṣaṣṭiḥ]N_p, saṣṭaṃ N, ṣaṣṭa ~~N_p~~

M: For certain people who are concerned with the rules (of astronomy), it is desirable to follow the opinion of the sage Vasiṣṭha (as far as the *yuga* is concerned); for the best of the Greeks, the *yuga* of the Sun and the Moon consists of 165 years.

P: Some who are students of the laws (of astronomy) find that it is good to follow the opinion of the sage Vasiṣṭha; (but according to) the best of the Greeks (the *yuga*) should consist of 165 years.

Note: As Pingree pointed out, the opinion of Vasiṣṭha may be that of *Vasiṣṭhasamāsasiddhānta* summarized in Ch.2 and Ch.17 of Varāhamihira's PS. From the *Vasiṣṭhasamāsasiddhānta* as we have now, there is no mention of *yuga*, leaving us rather clueless as to what this might be. What we do know about the *Vasiṣṭhasamāsasiddhānta* is that its epoch was set to 499 CE.[91] As Pingree had dated the YJ to the second/third century CE on the two falsely assumed *bhūtasaṃkhyā* passages (vv 60, 62), he explained that this *Vasiṣṭhasamāsasiddhānta* must be a later version of a pre-second/third century *Vasiṣṭhasiddhānta*, and this is "perhaps the date at which the original *Vasiṣṭhasiddhānta* was turned into the *Vasiṣṭhasamāsasiddhānta* available to Varāhamihira".[92] With the date of the YJ now put into question, the possibility of a later date of composition of the work of Vasiṣṭha referred to in this verse, i.e., after the epoch of the *Vasiṣṭhasamāsasiddhānta*, should not be excluded. Furthermore, if this work of Vasiṣṭha uses the same epoch of the *Vasiṣṭhasamāsasiddhānta* (499 CE), the *terminus post quem* of the VJ would be pushed to early sixth century.

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91 Pingree 1973: 2.

92 Ibid; Neugebauer & Pingree 1970-71: I.10.

The emended reading *yugo ravīndvor* here was not given in Pingree's 1978 edition but the description of a "luni-solar *yuga*" (in parentheses) may be noted in Pingree's earlier translation of the verse found in his studies of the *Vasiṣṭhasiddhānta* of the PS which I shall quote here:[93]

> "By following the opinion of the sage Vasiṣṭha some of those concerned with (astronomical) rules (believe that this great lunisolar yuga) is best; for those led by the Yavana... (the lunisolar yuga) is 165 years."

The expression for luni-solar *yuga*, *yugo ravīndvos*, if emended correctly, may refer the fact that in the mind of the author Sphujidhvaja, the cycle was devised to reconcile solar and lunar motions, unlike the smaller *yuga* which carried the sole purpose of eclipse prediction. As shown in the next verse, this *yuga* is characterized by the conjunction of the Sun and the Moon at its very start.[94] Similar expression for the luni-solar *yuga* is attested in the *Romakasiddhānta* of the PS.[95] The period of 165 years contains 61 intercalary months (v.10), 1,980 solar months and 2,041 synodic months, and it is not attested in any Greek source as Pingree noted. On the other hand, in the case of the *Romakasiddhānta*, the period of 2,850 years which contains 1,050 intercalary months, 34,200 solar months and 35,250 synodic months may be reduced to the well known Metonic cycle of 7 intercalary months in 19 years by the factor of 150, showing its Greek connection.[96] This is not the case for the agorithm of the YJ, where the multiples of the Metonic cycle are not adopted.[97] It is possible that this luni-solar *yuga* of the "best among the Greeks" may be an attempt to improve on some preexistent algorithms. See §III.4.1 for a comparison of the astronomical constants from the various texts.

<u>Definition of the beginning of the (luni-)solar *yuga*</u>

N100v1

tadādyatithyādi yugādi sauraṃ[A] meṣādibhāgasthit^{i}yo[B] ravīndvoḥ[C] |
meṣodaye[D] prāgṛtucaitraśukle pravartate[E] mānagatiḥ[F] krameṇa ||4||

[A] sauraṃ]~~N~~$_p$(emend.), saure N [B] sthit^{i}yo]emend., sthitiyo N, sthitayo p_{ed}
[C] ravīndvoḥ]p_{ed}, ravindoḥ N [D] meṣodaye]p_{ed}, meṣādayo N [E] pravartate]emend., pravṛttite N
[F] mānagatiḥ]emend., mānagati N

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93 Neugebauer & Pingree 1970-71: I.10.

94 However, elsewhere the *yuga* was referred to as just "solar" (vv. 4, 14).

95 PS 1.15ab: *romakayugam arkendvor varṣāṇy ākāśapañcavasupakṣāḥ* (2850). "The luni-solar *yuga* of the *Romaka Siddhānta* consists of 2850 solar years." (trans. Sastry).

96 Sastry & Sarma 1984: 17.

97 Furthermore, there is no indication of the influence of Hipparchus' tropical years on the YJ as it was evident on the *Romakasiddhānta* (see discussion in §III.3 and notes to v.34).

M: At the beginning of the solar *yuga*, which was the beginning of first *tithi* of that [luni-solar *yuga*], when the Sun and the Moon were [in conjunction] at the first degree of Aries (*meṣādibhāga-*), when Aries was in the ascendant (i.e., at dawn), on the bright fortnight (-*śuklapakṣa*) of *Caitra* in the Spring (*prāgṛtu-*), the source of measurement [of time] (*mānagati*), began to rotate progressively.

P: This solar *yuga* begins on the first *tithi* in the *śuklapakṣa* of *Caitra* in the Spring, when the Sun and the Moon in their courses are in conjunction in the first degree of Aries and when Aries is in the ascendant (i.e., at dawn).

Note: The beginning of a *yuga* set to the beginning of the white *pakṣa* of the month Caitra is largely standard across India. Although the import of the verse appears to be clear, the grammatical construction remains problematic. To construe *meṣādibhāgasthityos* with *ravīndvos* as a locative absolute construction, I had to resort to the gemination of the glide (y > iy, cf. Siever's law, attested mostly in Vedic but found occasionally in classical literature) so that the verse may scan properly. Alternatively, Pingree's emendation *sthitayo* (as accusative plural) may be adopted if *ravindoḥ* in N is emended to *ravīndū* (as accusative dual), noting the disagreement in number. As I cannot come up with a better solution, I have opted for the former, which requires the least emendation from the manuscript.

Relation between *tithi* and civil day; Omitted *tithis* in a *yuga*

N100v1-2

dinaṃ catuḥṣaṣṭi[A]lavonam āhus tithiṃ[B] dyuśabdākhyam[C] ahas tu sarvam |
triṣaṣṭibhāgena yutaṃ[D] sahasraṃ yuge 'vamānām[E] apasaptaṣaṭkam[F] ||5||

[A] catuḥṣaṣṭi]p_{ed}, catuṣaṣṭi N [B] āhustithiṃ]~~N~~$_p$ (emend.), āhuḥstithi N

[C] dyuśabdākhyam]emend. YOKOCHI, yuśabdāntyam N, praśabdāntyam ~~N~~$_p$, praṣaṣṭyantyam p_{ed} s_{ed}

[D] triṣaṣṭibhāgena yutaṃ]s_{ed}, triṣaṣṭibhāgaṃ navataḥ N, dviṣaṣṭibhāgaṃ navatiḥ p_{ed}

[E] vamānām]s_{ed}, tumānām N, tv ṛtūnām p_{ed} [F] apasaptaṣaṭkam]Ns_{ed}, apaśuddhaśatam p_{ed} (unmetrical)

M: They say that a day (*dinam*) minus 1/64 [of a day] is a *tithi*; on the other hand, a day (*ahar*), called by the word *dyu*, is one whole [*tithi*] plus 1/63 [of a *tithi*]. The number of omitted *tithis* (*avama*) in a *yuga* is equal to 1000 minus "7 times 6" (i.e. 1000 - 42 = 958).[98]

P: They say that a *tithi* equals a day minus 1/64th, but that every day equals a *tithi* plus 1/60th. In a *yuga* there are 990 seasons (*ṛtu*), (each) consisting of 62 (*tithis*).

Note: The verse spells out the relation between a *tithi* and a day. As a *tithi* is an artificial

[98] Following Shukla 1989.

unit, technically defined as a synodic month divided by 30, it is bound to be lesser than a day, resulting in generally more *tithis* than days in any given period. Since a day is associated with the *tithi* from which it begins, the lesser number of *tithis* result in the so-called omitted *tithi* (*avama*), which is by definition the number of *tithis* minus the number of days in a given period. Shukla's emendation of pādas *cd* is well justified - the important number 958 as given in the text is supported elsewhere in the text itself: 61230 (number of *tithis* in a *yuga* [v.6]) - 60272 (number of civil days in a *yuga* [v.7]) = 958 omitted number of *tithis*. In this verse, Pingree made a series of emendations, completing obliterating the numbers given by the manuscript and rather ungrammatically construed his version of one *yuga* consisting of 990 seasons (original 1000 - 7 × 6 = 958), each of 62 *tithis* (original: 1/63), noting himself however the discrepancy between the resultant 61,380 *tithis* in a *yuga* and the correct number of 61,230 (v.6).

Beside the problem of discrepancy, Shukla also noted Pingree's wrong mathematics: d = $t + t/63$, not $t + t/60$. However, Shukla's suggestion of "correction up to 1/60 of 1/60" appears irrelevant; further investigation will be required to reconstitute pādas *bc* properly. At any rate, Pingree's emendation of pāda *d,* with *śata* underlined with wavy line, is unmetrical. As for the day: *tithi* ratio of 64 : 63, as already pointed out in §III.3, it is most likely an approximation derived from number of *tithis* in a *yuga* : number of days in a *yuga*. Thus,

$$\frac{61230}{60272} = 1 + \frac{958}{60272} = 1 + \frac{1}{62 + \frac{876}{958}} = 1 + \frac{1}{62 + \frac{1}{1+\frac{82}{876}}} \approx 1 + \frac{1}{62+1} = \frac{64}{63}.$$[99]

<u>Importance of *tithis* and number of *tithis* in a *yuga*</u>

N100v2

krameṇa candra[A]kṣayavṛddhilakṣyas tithiś caturmānavidhānajīvam[B] |
ṣaṭpañcakāgrā dviśatī[C] sahasraṃ teṣāṃ[D] yuge[E] viddhy ayutāni[F] ṣaṭ ca ||6||

[A] candra]Ns_{ed}, candraḥ ~~N~~$_p$ [B] jīvam]N, bījaḥ $p_{ed}s_{ed}$, [C] kāgrādviśatī]Ns_{ed}, kāgre dviśate p_{ed}
[D] teṣāṃ]$p_{ed}s_{ed}$, teṣā N [E] yuge]$p_{ed}s_{ed}$, yudhi N, pradhi ~~N~~$_p$ [F] viddhy ayutāni°]s_{ed}, vidyayutāni N, binduyutāni p_{ed}

M: <u>The *tithi*, which is to be defined by the gradual waning or waxing of the Moon, is the soul</u> of the principles of the four (systems of time-)measurement. <u>Know that there are 60,000 plus 1000 plus 200 and 6 × 5 (i.e. 61,230) of them (i.e., *tithis*) in a *yuga*.</u>"[100]

P: The Moon is to be characterized by waning and waxing in order. The *tithi* possesses the seed of the principles of the four (systems of time-)measurement. There are 60,265 (days) in a *yuga*.

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[99] As Hayashi informed me, this is a popular method of approximation in India.

[100] Following Shukla 1989.

Note: The four systems of time measurements are given and they are: *saura* (solar), *cāndra* (lunar), *sāvana* (civil) and *nākṣatra* (sidereal).[101] As we shall see, the number of *tithis* proposed in this verse is closely related to the definition of 2,041 synodic months in this *yuga* of 165 years. The main problem of Pingree's reading of this particular verse lies on the fact that he assumed the *teṣām* in pāda c to refer to *dina* as opposed to *tithi*, leading to his suggestion that "a more logical order might be achieved by interchanging 6c-d with 7c-d". As Shukla pointed out, the verse concerns entirely the number of *tithi* in a *yuga* and the numbers in pādas *cd* require no emendation. Pingree's fantastic emendation of *binduyutāṇi ṣaṭ* to mean 60 leads also to his audacious and subsequently highly misleading statement - "If my restoration... is correct, this is the earliest reference known to the decimal place-value system with a symbol for zero (*bindu*) in India. The extreme clumsiness with which Sphujidhvaja expresses numbers is a reflection of the fact that a satisfactory and consistent method of versifying them had not yet been devised in the late third century." This remark is problematic because elsewhere the author of this chapter had no problem expressing himself mathematically without the use of zero or the explicit reference to a place-value system. Thus as Shukla pointed out, Pingree's reading 60,265 is completely wrong and the correct reading is in fact given in his own apparatus. The last line should thus read 60,000 (*ayutāṇi ṣaṭ*) plus 1,000 (*sahasram*) plus 200 (*dviśatī*) plus 6 × 5 (*ṣaṭpañcakāgrā*). The formulation of one *yuga* equals 61,230 *tithis* is in agreement with the formulae stated in vv. 9 and 20.

Pingree's erroneous reading of 60,265 civil days in a *yuga* based on his wrong interpretation of the anaphora *teṣām* result in a number of inconsistencies in his calculation (§III.3).[102]

Shukla's emendation of *viddhi* as the main verb may be justified by similar usage found in v.54. The use of *agra* to indicate the remaining or additional part against the main part of a number is characteristic of this text.

Another noteworthy point about this verse is the emphasis on the *tithi* as the "soul" (*jīva*) of the four calculations. The importance of *tithi* may be summarized by the words

[101] Pingree believed that the four categories of time-measurements belong to the early medieval period since they were first enunciated in the *Paitāmahasiddhānta* quoted in *Viṣṇudharmottarapurāṇa* 3.1, a work dated to early fifth century CE according to Pingree, but suggested that they were hinted earlier as in this verse (Pingree 1973: 3,11fn14). Kumārajīva in his *Dazhidulun* 大智度論 (405 CE), commentary on the *Pañcaviṃśatisāhasrāprajñāpāramitā*, described the four types of months: "There are four types of month - first, solar month; second, civil month; third, lunar month; fourth, sidereal month." 有四種月：一者、日月，二者、世間月，三者、[25]月月，四者、星宿月。(T25.1509.409c). As Kumārājīva arrived in Chang'an in 402 CE and lived in Khotan in the second half of the fourth century, we can safely assume that such knowledge was common enough in the Indian subcontinent during the second half of the fourth century to spread to Central Asia.

[102] Pingree 1978b: 538.

of Sastry in the notes to his new reading of PS 1.4, where *tithi* was unwarrantedly emended to *kṛta* by Thibaut/Dvivedi and to *stvatha* by Neugebauer/Pingree: "...[the *tithi*] is the chief of the five *aṅgas,* viz. *tithi, vāra, nakṣatra, yoga* and *karaṇa*...[it] is most useful not only for religious but also civil purposes, ...[it is] the *sine qua non* of all astronomical computation".[103] The number of *tithis* is first stated here as the basis of some of the remaining calculations. The use of *tithi* is not attested in any Greek work extant and the importance given to it in this work may suggests this formulation of the "best of the Greeks" may be the work of the Greek community long settled in India with great familiarity with the indigenous systems, rather than a translation of a "lost work composed in Alexandria" with sporadic Indian flavors as Pingree suggested.

Definition of *dinarātra* and number of civil days (rising of Sun) in a *yuga*

N100v2-3

triṃśanmuhūrtaṃ dinarātram uktaṃ[A] sūryodayāt kālabudhās tad āhuḥ |
teṣāṃ śate[B] dve trikṛdaṣṭakāgre[C] ṣaṭ cāyutāny[D] arkayugaṃ vadanti ||7||

[A] uktaṃ]p_{ed}, ukta N [B] śate]p_{ed} s_{ed}, sate N [C] trikṛdaṣṭakāgre]~~N~~$_{p}$$s_{ed}$, ttrikṛdaṣṭakāgre N, triśad ekakāgre p_{ed} [D] ṣaṭcā°]N, ṣaṭkhā° p_{ed}, ṣaṭkā° s_{ed}

Shukla 1989: A nychthemeron (civil day) is said to consist of 30 *muhūrtas*; experts on time say that it begins with sunrise. They say that a *yuga* of the Sun consists of 60,000 plus 200 plus $3^2 \times 8$ (i.e. 60,272) of them (civil days).

P: A nychthemeron is said to consist of 30 muhūrtas; experts on time say that it begins with sunrise. They say that a *yuga* of the Sun consists of 61,230 (*tithis*).

Note: Here Pingree once again claimed a case of place-value system with a symbol for zero (*ṣaṭ khāyutāni*) as he did in the previous verse. *kha* was in fact an unnecessary emendation. *ṣaṭ cāyutāni* to means 60,000 is perfectly fine as it is similar to the previous verse.

Risings of Moon and asterisms in a *yuga*

N100v3

ekādhikās[A] triṃśaśatadvayāgrāḥ[B] pañcāśad aṣṭau ca sahasranighnāḥ |
candrodayāḥ syur yugavarṣamiśrās[C] tv arkodayās te bhagaṇodayāḥ syuḥ ||8||

[A] ekādhikās]p_{ed}, ekādhikā N [B] °śatadvayāgrāḥ]p_{ed}, °satadvayāgrā N [C] miśrās]N, hīnās p_{ed}

M: The risings of the Moon (in a *yuga*) are 58,231; the risings of the asterisms are equal to the rising of the Sun plus the number of years in a *yuga*.

P: The risings of the Moon (in a *yuga*) are 58,231; the risings of the Sun (i.e., civil days)

[103] Sastry 1993: 5.

are equal to the risings of the constellations minus the number of years in a *yuga*.

Note: In a *yuga*, the number of sidereal rotation, or rising of the asterisms from the East (*bhagaṇodayās*) resulted from the Earth's rotation, equals to the sum of the risings of the Sun from the East (*arkodayās*) and the number of revolutions of the Sun from West to East: $R_n = D + R_s$. The apparent retrograde motion of the planets was the basis for the calculation of the mean motions of the planets in all Siddhāntic texts. The number of revolutions of the Sun (against the fixed stars) is equivalent to the number of solar years and hence accounts for the expression "number of years in a *yuga*" (*yugavarṣa-*) in this verse. This is an intuitive way to account for the fact that the stars rotate faster than the Sun, the Moon and the remaining planets; in other words, the number of times the stars rotate is equal to the number of the Sun's risings plus the number of times it moves eastward. Naturally, this amounts to what Pingree has suggested: $D = R_n - R_s$. But the emendation is unnecessary.

Number of solar, lunar and sidereal months in a *yuga*

N100v3-4

śate dvikone[A] daśakāhate ca[B] yugādhimāsaiś ca yutaṃ tad eva |
śatadvayaṃ ṣaṭ[C] dviguṇaṃ[D] sahasraṃ yuge syur arkendusamāsasaṃkhyāḥ ||9||

[A] dvikone]emend., dvikoṇe N, dviśone p_{ed} [B] °kāhate ca]p_{ed}, °kāhatekā N
[C] śatadvayaṃṣaṭ]N, śaratriśat ṣaḍ p_{ed} [D] dviguṇaṃ]p_{ed}, dviguṇa° N

M: In one *yuga* the number of solar, lunar and combined (*samāsa*) [sidereal] months are 1,980, that plus the number of intercalary months in one *yuga*, and 2,206 [respectively].

P: (The number of solar months) is 1,980. If one joins this (number of solar months) with the number of intercalary months (*adhimāsa*) in a *yuga*, the number of conjunctions of the Sun and Moon (i.e., synodic months) is 2,041.

Note: The number of solar, synodic and sidereal months are given here in this verse in a condensed manner. Synodic month here is expressed here as the solar months in a *yuga* + the number of intercalary months which is given in the next verse. The sidereal month, which is the Moon's revolution, is expressed here as the *combined* month. This refers to the fact that the number of sidereal months in a *yuga* may simply be obtained by number of synodic month + number of Sun's revolution. The number given here, 2,206, may be cross-checked by adding all the numbers up: 1,980 (number of solar months) + 61 (number of intercalar months) + 165 (number of Sun's revolution) = 2206. Pingree's emendation of pāda *c* involves the use of *bhūtasaṃkhyā* (*śara*=5) which is not attested anywhere else in the text at all, as well as the impossible expression of *śaratriśat ṣaḍ* to mean 41 (= 5 + 30 + 6).

<u>Number of *adhimāsa* (intercalary months) in a *yuga*</u>

N100v3

yat sāvanārkaindavamāsakālād[A] viśiṣyate bhāskaracandrayoś ca |
ta ekaṣaṣṭiḥ śaśino 'dhimāsā jñeyāḥ svakālādiguṇakrameṇa[B] ||10||

[A] °rkaindava°]p_{ed}, °rkendrava° N [B] svakālādiguṇakrameṇa]p_{ed}, svakālādhiguṇakrameṇa N

P: There is something distinguished from the time of the civil, solar, and lunar (sidereal) months of the Sun and the Moon; these are the 61 intercalary months (*adhimāsas*) of the Moon, which are to be known by their qualities, such as their times.

Note: *Yuga* is to be supplied here, carried forward from the last verse. The *yuga* of the Sun and the Moon was expressed earlier in verses 3 and 4. Here, having introduced the sidereal month already in the last verse, the remaining three types of months are mentioned, as typically described in all later Hindu astronomical works such as *Sūryasiddhānta* 1.12-13: civil (*sāvana*), or 30 risings of the Sun; solar (*ārka*), or one solar year divided by 12; synodic (*aindava*), or the time from one new moon to the next. The number of intercalary months is obtained by taking the difference between the number of synodic months and the number of solar months. According to verse 6, the number of *tithis* in a *yuga* is 61,230; thus the number of synodic months in a *yuga* would be 61230 ÷ 30 = 2041. By definition, one solar year contains 12 solar months and hence a *yuga* of 165 years would contain 1,980 solar months. The difference is therefore 61. The number intercalary months is important in the calculation of civil days in a synodic month in verse 12. The "respective beginning of time" for each month refers to the different starting point which defines each month. Hence, for the sidereal month, the Moon's entrance to the same *nakṣatra*; for the civil month, the first counting of the cycle of 30 days; for the solar month, the Sun's entrance to the same *nakṣatra* equally divided by 12; for the synodic month, from one conjunction of the Sun and Moon to the next.

<u>Number of civil days in a civil month and a solar month</u>

N100v4-5

triṃśaddināḥ[A] sāvanamāsa ārkas tryagrair viśiṣṭo[B] daśabhir muhūrtaiḥ |
kalācatuṣkeṇa[C] ca pañcaṣaṭkais[D] tryagryāṃśakaiś[E] ca dviguṇaiś caturbhiḥ ||11||

[A] dināḥ]p_{ed} s_{ed}, dinā N [B] °stryagrairviśiṣṭo]s_{ed}, °stryaṅsairviśiṣṭo N, °stryaṃśeviśiṣṭā ~~N~~$_{p}$, °s tryagrair viśiṣṭā p_{ed} [C] kalā°]N_{pc}, kāla° N_{ac} [D] °ṣaṭkais°]$p_{ed}s_{ed}$, °ṣaṭkaḥ N, °ṣaṭkas° ~~N~~$_{p}$ [E] °tryagryāṃśakaiś°]$p_{ed}s_{ed}$, tryagryāṅsakaiś° N_{pc}, tryagryāṅkaiś° N_{ac}

M: A civil month (*sāvanamāsas*) equals 30 days. A solar month is augmented by 10 + 3 *muhūrtas*, 4 *kalās* and (2 × 4) / (5 × 6 + 3) of a *kalā*.[104]

[104] Following Shukla 1989.

P: A civil month equals 30 days, a solar month equals (a civil month) plus 13 *muhūrtas* and 4 *kalās* and 56 thirds and 2 fourths.

Note: The formula gave the number of civil days in a solar month: 30 days + 13 *muhūrtas* + 4 + 8/33 *kalās*. Based on the number of civil days in a *yuga* described in verse 7, the number of days in a solar month should be 60272 ÷ (12 × 165) = 30 + 872/1980. As 20 *kalās* = 1 *muhūrta* and 30 *muhūrtas* = 1 civil day (verses 28-29), 872/1980 d = 13 *muhūrtas* + 8400/1980 *kalās*, which agrees with the figure here. Pingree once again made the same mistake of reading *pañcaṣaṭka* as 56 instead of 30 as he did earlier in verse 6. Together with his wrong interpretation of one *muhūrta* = 60 *kalās* (influenced possibly by Bhāskara's definition, see notes to vv.29, 32), his reading of the number of civil days in a solar month does not agree with the algorithm provided earlier and is therefore incorrect.

<u>Number of civil days in a synodic month</u>

N100v5

ahnāṃ tu[A] ṣaṭpañcakam ekahīnaṃ kṣaṇāṣṭakau dvau dvikalāvihīnau |
kalālavāḥ[B] sapta śatī dviṣaṣṭā[C] svamāsabhinnāḥ[D] śaśinaḥ sa māsaḥ ||12||

[A] ahnāṃ tu]s_{ed}, ahnā tu N, ahnas tu p_{ed} [B] kalālavāḥ]p_{ed}, kalālavā N [C] sapta śatī dviṣaṣṭā]~~N~~$_p$ s_{ed}, śaptasatīdviṣaṣṭā N, śataṃ vidiṣṭaḥ p_{ed} [D] svamāsabhinnāḥ]N, svamāsabhinnā s_{ed}, samāsabhinnaḥ p_{ed}

M: The (synodic) month of the Moon equals to 6 × 5 - 1 (= 29) days, 2 × 8 *kṣaṇas* (16 *muhūrtas*) minus 2 *kalās*, and a fraction of a *kalā* equal to 762 divided by (the number of) its months (in a *yuga*, i.e., 2041).[105]

P: A (synodic) month of the Moon, which ends with a conjunction, consists of 29 days and 32 *kṣaṇas* minus 4 *kalās* and 107 sixtieths of a *kalā*.

Note: The number of synodic months in a *yuga* equals to the number of civil months in a yuga (12 × 165) plus the *adhimāsa* (61, cf. verse 10) and is hence 2041. Since the number of civil days in a *yuga* is 60272 (verse 7), the number of civil days in a synodic month would be 60272 ÷ 2041. Taking again the conversion from verses 28-29, this works out to be 29 days 15 *muhūrtas* 18 + 762 ÷ 2041 *kalās*, which agrees with the expression 29 days 16 *kṣaṇas* - 2 *kalās* + 762 ÷ 2041 *kalās* as Shukla suggested, although the "correct readings" were not given exactly in the apparatus as Shukla claimed, but rather with some slight emendations.

<u>Number of civil days in a sidereal month</u>

N100v5-101r1

ārkṣas trikṛt[A] trir dyugaṇas[B] tri[C] kṛc ca kṣaṇāḥ[D] kṣaṇārdhaṃ ca kalāś ca tisraḥ[E] |

[105] Following Shukla 1989.

kalāṃśakānāṃ ca trisaptakāgraṃ śataṃ vibhaktaṃ[F] dalitaiḥ svamāsaiḥ[G] ||13||

[A] ārkṣastrikṛt]s_{ed}, ārkṣastukṛt p_{ed}, arkṣastukṛt N [B] rdyugaṇas°]s_{ed}, rdviguṇas p_{ed}, dviguṇās N
[C] tri]s_{ed}, tu N [D] kṣaṇāḥ]p_{ed}, kṣaṇā N [E] tisraḥ]p_{ed}, trisraḥ N [F] vibhaktaṃ]Ns_{ed}, vibhakto p_{ed}
[G] svamāsaiḥ]emend., samāsaiḥ N

M: A sidereal month consists of $3^2 \times 3$ days (*dyugaṇa*?), 3^2 *kṣaṇas* (*muhūrtas*) plus half a *kṣaṇa*, 3 *kalās* plus a fraction of a *kalā* which equals to 121 divided by half (the number) of its month (in a *yuga*, i.e., 2,206).[106]

P: A sidereal month consists of 27 days plus 8½ *kṣaṇas* and 3 *kalās* and 137 sixtieths of a *kalā*; it is separated by half-conjunctions (?).

Note: Similar to the previous verse, the calculation of the number of civil days in a sidereal month should yield to 60272 ÷ 2206 (v.9). To confirm the reading of this verse, assume once again 27 days in one sidereal month. Since there are 2206 sidereal months in one *yuga* of 165 years (v.9), 27 days in one sidereal month would make 59,562 days in a *yuga*. The difference of civil days in a year is (60272 - 59562) ÷ 2206 day = 710 ÷ 2206 day = 426000 ÷ 2206 *kalās*. The expression 9.5 *kṣanas* and 3 + 121 ÷ (2206 ÷ 2) *kalā* is equivalent to 213000 ÷ 1103. Pingree's interpretation is not possible not only because his emendation is baseless, but also for the fact that he had not taken the verse in its entirety. Shukla's emendation *dyugaṇas* may be justified as it supplies "day" as the unit, but the expression itself is uncommon.

Beginning of the solar *yuga* measured against the Śaka era

N101r1
gate ṣaḍagre[A] 'rdhaśate samānāṃ kālakriyāntatvam[B] idaṃ śakānām |
ravir yuge[C] sūryadine prapede[D] kramāt tadabdādi yugādi bhānoḥ ||14||

[A] ṣaḍagre]N, ṣaḍ eke p_{ed} [B] kālakriyāṃtatva°]N, kālakriyātattva ~~N~~$_p$ [C] ravir yuge]emend., raveyuśaṃ N, raveruṣe p_{ed} [D] prapede]emend., praderkaḥ N, †prade 'rke† p_{ed}

M: When 56 years (of the *yuga*) have gone, this (i.e., the following) is the (upper) limit of the reckoning of time for the Śakas - On a Sunday in the *yuga* of the Sun, the Sun moved progressively; the beginning of that year is the beginning of the *yuga* of the Sun.

Falk 2001: When 56 years (of the *yuga*) have gone, this is the state of (the sky leading to) the epoch of the Śakas...

P: When 66 years of the Śakas have elapsed, that is the truth (i.e., foundation) of the calculation of time. At dawn on Sunday begin that year and the *yuga* of the Sun.

[106] Following Shukla 1989.

Note: According to Falk's interpretation, the solar *yuga* commences 56 years before the Śaka era (78 CE) or in other words, 22 CE. Pingree noted that *ṣaḍagre 'rdhaśate* should read 56 or 156 (?), but decided to emend it to *ṣaḍeke 'rdhaśate* to mean 66 (!) or 166 (?) as the former leads to the year 144 CE which Pingree believed to coincide with the conjunction of the Sun and Moon at *meṣādi*. Falk's suggestion of 22 CE which took the reading more faithfully matches the astronomical requirement of the conjunction of Sun and Moon in Aries. This led Falk to suggest that 22 CE was the date "when people from the West (*yavana*) spread their astronomical knowledge in South Asia", coinciding "with the early years of Gondophares' rule in India".[107] However, as Yano had pointed out to me, all these beginnings of eras are mostly to be backward calculation by astronomers just like the Christian era which was created in the 5th century CE. In addition, Falk highlighted the astronomical significance of the Śaka era (78 CE), the year (April 1 to be precise) when the Sun, Moon and Jupiter conjoin in Aries, which could well signify a Jupiter *yuga* system.[108]

Koṣāṇa era as elapsed years from the *yuga*

N101r1, U(BJ7.9)

gatena sādhyardhaśatena[A] yuktyā[B] vyekena[C] koṣāṇagatābdasaṃkhyā[D] |
kālaḥ[E] śakānāṃ pariśodhya[F] tasmād atītam anyad yugavarṣayātaṃ[G] ||15||

[A] sādhyardha°]N, sābhyardha° $U_{BJ7.9}$ [B] yuktyā]N, yuktā Up_{ed} [C] vyekena]N, pyaṃkena U, pyekena $U_{(pingree)}$ [D] koṣāṇagatā°]~~N~~$_p$, koṣāṇaśatā° N, keṣāṃ na gatā° U [E] kālaḥ]NU, kālaṃ p_{ed} [F] śakānāṃ pariśodhya]N, śako1044nāṃ śaviṃśodhya U [G] °datītamanyadyugavarṣayātaṃ]emend., °datītamanyayugavarṣayātaṃ N, °datītamanyadyugavarṣayātaṃ ~~N~~$_p$, °datītavarṣād yugavarṣajātam U, °datītam anyad yugavarṣayātāḥ Falk2001, °datītavarṣā yugavarṣajātāḥ p_{ed}

Falk 2001: The elapsed years of the Kuṣāṇas in combination with 149 (change into) the time of the Śakas. Subtracting from this (Śaka time [plus 56]) the elapsed (*yuga*, i.e. 165 years) (produces) the elapsed (*yātāḥ*) [years] of the years of the second *yuga*.

P: Take the number of years that have passed of the Koṣāṇas, add 149, and subtract from this (sum) the time of the Śakas (i.e., the year in the Śaka era); (the remainder) is the number of years in the *yuga* which have elapsed.

Note: Pingree claimed that N's reading pāda *d* does not permit the dating of the Kuṣāṇas but one may hypothetically interpret "the epoch of the Kuṣāṇa era fell 149-66 = 83 years before A.D. 144 or in A.D. 61" if one modifies Utpala's reading.[109] However, based on

[107] Falk 2001: 133.

[108] Ibid.

[109] Pingree 1961-1962: 18 fn6; 1978 II: 408-9.

Falk 2001's re-reading, the Kuṣāṇa era should be 149 years from Śaka era (78 CE) or in other words 227 CE.[110] As this date appears to be too late for Kuṣāṇa history, Falk adopted the theory "omitted hundreds" first proposed by van Lohuizen-de Leeuw in 1949 and that "*meṣasaṃkrānti* of 127 CE is the real starting-point of the Kaniṣka era".[111] As some scholars have pointed, this solution suggested that Sphujidhvaja was unaware of this phenomenon of "omitted hundreds" and that the Kuṣāṇa era was merely 49 years after the Śaka era; Falk's proposal remains speculative although attempts to defend it.[112] In pāda *d*, Falk interpreted *anyad* as referring to the second *yuga* since by the time of the Kuṣāṇa era, the first *yuga* has already passed and the second *yuga* has already started on 28 March, 187 CE.[113] Falk's emendation of *anyad* was probably prompted by metrical reason and not from Utpala as Falk himself claimed.[114]

Calculation of elapsed *tithis*

N101r2

yuge[A] gatābdās[B] tricatuṣkanighnās tadabdamāsādhikamāsayuktāḥ |
triṃśadguṇās tattithibhiḥ[C] sametāḥ pṛthaksthitās te ca tithivyatītāḥ[D] ||16||

[A] yuge]*p*, yugaṅ N [B] gatābdās]~~N~~$_p$, gatābdā N [C] tattithibhiḥ]emend., tetithibhis N
[D] pṛthaksthitāstecatithivyatītāḥ]emend., pṛthagyugābdaiḥsahitāvyatītaiḥ N

M: The number of elapsed *tithis* [at a given time] equals to the elapsed years in the *yuga* multiplied by 12, increased by the (lapsed) months and intercalary months of that year, multiplied by 30, plus the (elapsed) *tithis* of that [current month]. This number is placed separately.

P: The elapsed years in the *yuga* are to be multiplied by 12 and increased by the (lapsed) months and intercalary months of the present year; this sum is to be multiplied by 30 and joined with the (lapsed) *tithis* (of the current month) and with the epacts (in *tithis*) of the individual (lapsed) years of the *yuga*.

Note: The formula here describes the typical calculation of the number of elapsed *tithis*, that is, $t = [y' \times 12 + (m' + a')] \times 30 + t'$. The term *pṛthak* is used typically in the algorithm to indicate a lump sum which is to be used repeatedly in the arithmetic operation, which is typically the case of the calculation of *ahargaṇa* as in SS (see note under v.17).

110 Falk 2001: 126.
111 Falk 2001: 130.
112 Neelis 2007: 88-89; Falk 2007: 134,143 fn3,4.
113 Falk 2001: 130.
114 Mukherjee 2004a/b; Falk 2007: 135.

<u>Calculation of elapsed *avamas* (missing *tithis*)</u>

N101r2

caturdhanacchannaphalaṃ[A] tato yad[B] gatāvamās te dinarātriśeṣam[C] |
viśodhya[D] ṣaṭpañcaguṇā ahobhir[E] labdhā muhūrtās tithiśeṣagās te |17||

[A] caturdhanacchannaphalaṃ]~~N~~$_p$(emend.), caturddhanacchannaphala N, ahargaṇaṃ channaphalaṃ p_{ed}
[B] yad]p_{ed}, ya N [C] ste dinarātriśeṣam]emend., stā dinarātriśeṣam p_{ed}, stā svaharātriseṣan N
[D] viśodhya]N, vihanya p_{ed} [E] pañcaguṇā ahobhir]emend. pañcaguṇāḥ svahāraḥ N, pañcaguṇair dināni p_{ed}

M: <u>Subtract the number of leftover days from the number of lapsed *avamas* (omitted *tithis* at a given time), which is the result of the concealed result of the fourfold sum (*caturdhanacchanaphalam*), multiplied by 30, divided by the numbers of civil days, the result will be the number of *muhūrtas* elapsed in the leftover *tithi*.</u>

P: From this (one gets) the day-number with a concealed result (*ahargaṇachannaphala*), which (consist of) the *avamas*; these (*avamas*) are the difference between (the lapsed *tithis*) and the nychthemera. If one multiplies the "days" by 30, the result is the number of *tithi-muhūrtas*.

Note: Pingree remarked: "With verse 17 one finds the *avamas*, which are the difference between the number of *tithis* and the number of civil days. My interpretation of the second half of this verse is extremely dubious; one expects a rule for calculating the lapsed *avamas*." Pingree was indeed correct in pointing out that the calculation of lapsed *avamas* is expected here. Instead, the conversion of the fraction left from the elapsed *avamas* to *muhūrtas* is given here, i.e., by simply multiplying 30. The missing calculation should be: multiply the sum that was placed separately (*pṛthaksthās*) in v.16 by the number of *avamas* in *yuga* (958 [v.5]) and divided by number of *tithis* in a *yuga* (61,230 [v.6]). The expressions in the SS 1.50 are: *dviṣṭhās tithikṣayābhyastāś cāndravāsarabhājitāḥ*. In formula expression, this would be: $u = t \times U \div T$. The missing calculation could be one of the missing verses based on the numbering in Q.[115]

<u>Calculation of elapsed days and the determination of *nakṣatra*/planetary days</u>

N101r2-3

gatāvamonaṃ tu gaṇaṃ[A] tithīnāṃ vindyād yugātītadināni tāni |
tato 'rkṣamāna[B]grahavāsarāṇāṃ tatrārthanāyām anumānam icchet ||18||

[A] tu gaṇaṃ]p_{ed}, tu guṇa N_{ac}, guṇaka N_{pc}, guṇa(kaṃ) N_p [B] tato' rkṣamāna]emend.,
śatarkṣamāna N, saptāṅgamānaṃ p_{ed}

M: <u>On the other hand,</u> one would find the number of (civil) days elapsed in the *yuga* to be the number of (elapsed) *tithis* minus the number of lapsed *avamas*. <u>From that [number of</u>

115 Mak 2013: 4 fn.10.

ahargaṇa], one may seek inference for the obtaining of day based on calculation of *nakṣatra* (*ṛkṣamāna-*) or the planets.

P: One should find that the number of (lapsed) *tithis* diminished by the number of lapsed *avamas* equals the number of (civil) days which have passed in the *yuga*. There is a seven-fold measure of the planetary week-days; in seeking the answer to this, one desires (the use of) inference (*anumāna*).

Note: The first half of this verse completes the *ahargaṇa*, i.e., D = t - u. The inference described here refers to the way the sum of days since the epoch (*ahargaṇa*) may be used to determine the planetary deity and presiding *nakṣatra* of the day. The exact calculation of the planetary weekday, month and year are given later in vv. 52-54.[116] The calculation of the presiding *nakṣatra* for the day is also typical of the *pañcāṅga*, though it is not explained fully here.

Calculation of intercalary months elapsed in a given period

N101r3
ekādaśaikādaśabhāgayutyā[A] yugād gatābdān[B] vihatān[C] vibhajya[D] |
ṣaṭpañcakenādhikamāsakās te dvikaṃ diṇāḥ[E] sāvanasūryayos tu ||19||

[A] °daśabhāgayutyā]emend., °dabhāgayuktyād N, °daśabhāgayutya s_{ed}, °da<śa>bhāgayuktyā p_{ed}

[B] °ābdān]$p_{ed}s_{ed}$, °ābdād N [C] vihatān]$p_{ed}s_{ed}$, yuganāṃ N [D] vibhajya]$p_{ed}s_{ed}$, vibhejyā N

[E] dvikaṃdināḥ]emend., dvihañjiṇās N_{pc}, dvihaṇās N_{ac}, dvihaṃ (ji)ṇāḥ p_{ed}

M: The number of intercalary months (in a given period) is the number of years passed in the *yuga*, multiplied by (11 + 1/11) and divided by 30. However, the [two kinds of] days in civil and solar units [are to be calculated] in a twofold manner.

Shukla 1989: The number of years which have passed of the *yuga*, multiplied by (11 + 1/11) and divided by 30 gives the number of intercalary months (in that period)...

P: The number of years which have passed of the *yuga* is to be multiplied by 11;11 and divided by 30; (the result is the number of lapsed) intercalary months… in (of?) the civil (day? month?) and the Sun.

Note: To prove whether the formulation is correct, let us multiply the number of solar years in a *yuga*, 165, by (11 + 1/11) and divide by 30. The result is 61 intercalary months which agrees with the number given in v.10. The fraction 122 ÷ 11 or (11 + 1/11) *tithis* per year is simply obtained from (number of intercalary months per *yuga* × 30) / number of years in a *yuga* - i.e., 1830 ÷ 165 *tithis* per year. Pingree interpreted *bhāga* in pāda *a* as

116 Cf. SS 1.48-52 (Burgess 1858: 173-178).

1/60 which led him to the incorrect figure of 11;11 (or 11 + 11/60) instead of (11 + 1/11). Furthermore, he claimed the discrepancy between the total number of *tithis* in a year stated in this verse (360 + 11;11) and the number of *tithis* stated in verse 5 (62 × 6 = 362). Both numbers are wrong. The number "958 *tithis*" given in verse 5cd refers to the number of missing *tithis*, not the epacts. On the other hand, Pingree read correctly though inconsistently *ṣaṭpañcakena* as 30 instead of 56 as he did in v.11. Pāda *d* is expected to give the number of civil days converted from the intercalary months elapsed proportionally for the given period since the epoch.

<u>Calculation of lapsed *tithis* in a given period and the number of synodic months in a *yuga*</u>

N101r3-4

tithis[A] tadabdā[B]dhikamāsakaghnā[C] hāryā[D] ṣaḍekādaśapañcakena[E] |
pañcāṣṭakenaika[F]yutena yuktaṃ jñeyās tu māsā[G] dviguṇaṃ sahasram ||20||

[A] tithis]emend. HAYASHI, tithīs N [B] °stadabdā°]p_{ed}, °stadābdā° N [C] °sakaghnā]emend. HAYASHI, °sakāsair N, °sakai<ś ca> p_{ed} [D] haryā]emend. HAYASHI, hīnā N, hīnāḥ ~~N~~$_p$, hatāḥ p_{ed}

[E] ṣaḍekādaśapañcakena]emend. HAYASHI, paḍaikādaśakenahanyāt N, ṣaḍekādaśakena bhajyāt p_{ed}

[F] °kenaika°]emend. HAYASHI, °kekeṇa N, °kaikena ~~N~~$_p$ [G] jñeyās tu māsā]~~N~~$_p$ p_{ed}, jñeyotrahorā N

M: One should divide the product of the (number of) *tithis* (in a *yuga*) and the (number of) lapsed intercalary months <u>in that year by 61 (*ṣaḍekādaśapañcaka*)</u>; for there are 2041 (synodic) months (in a *yuga*).

P: One should multiply the (number of) *tithis* (in a *yuga*) by the (number of) lapsed intercalary months and divide (the product) by 61; for there are 2041 (synodic) months (in a *yuga*).

Note: According to Pingree, *ab* is the calculation of lapsed *tithis* based on the relation (*tithis* in *yuga*) : (lapsed *tithis*) = (intercalary months in *yuga*) : (lapsed intercalary month). Therefore, the lapsed *tithis* would be (*tithis* in *yuga*) × (lapsed intercalary months) / (intercalary months in a *yuga*) or (lapsed intercalary months) × 61230 ÷ 61. Although Pingree's translation is correct, but his emendation of *ṣaḍekādaśakena* in pāda *b* reads 66, not 61.

<u>Mean motion of the Sun and Elongation of the Moon</u>

N101r4

māsās tadabde[A] ravibhuktarāśīḥ saṃviddhi[B] ṣaṭpañcaguṇān[C] tu bhāgān |
horādhṛtaiḥ[D] sūryayutaḥ sa bhāgo labdho bhaven madhyamacārayoge ||21||

[A] māsās ta°]p_{ed}, lambāsta° N [B] saṃviddhi]p_{ed}, saṃdvidvi° N, sadvidvi ~~N~~$_p$

[C] ṣaṭpañcaguṇān]emend., ṣa<?>ñcaguṇās N, ṣa<ṭpa>ñcaguṇās p_{ed}

[D] horādhṛtaiḥ]emend., horādhṛtāḥ N, horādharaiḥ p_{ed}

M: The months of the years (are equal to) the signs traversed by the Sun; but know that the degrees (are obtained by) multiplying [the number of signs] by 30. The degree [for the Moon] in its mean motions would be obtained by those intended for astrology (*horādhṛtaiḥ*) to be (the elongation) plus the position of the Sun.

P: Know that the signs traversed by the Sun (are equal to) the months (which have passed) in the current year. These are multiplied by 30 to give degrees; then the degree occupied by the Sun in its mean motion is taken by the astrologers.

Note: *lamba* from N, which means latitude, does not seem to make sense here and Pingree's emendation is acceptable here. In pāda *c*, *sūryayutaḥ* means "increased by solar (position)" and does not mean "occupied by the Sun".

N101r4-5
tanmāsayātais tricatuṣkanighnair[A] ādityabhuktaṃ tithibhir yutaṃ tat |
rāśaiḥ[B] syur indo ravibhuktabhāgās[C] tebhyo bhaved iṣṭavimānam[D] īkṣya[E] ||22||

[A] °tricatuṣkanighner]emend., °tricatuṣṭanighner N, °tricatuṣṭanighnair ~~N~~$_p$

[B] rāśaiḥ]N, rāśeḥ ~~N~~$_p$, rāśīḥ p_{ed} [C] °bhāgā°]~~N~~$_p$(emend.), °bhogā° N [D] °vimānam]p_{ed}, °vinānam N

[E] īkṣya]~~N~~$_p$(emend.), īkṣyaḥ N

M: The (degrees) traversed by the Sun plus the number of *tithis* lapsed in that month multiplied by 12, would be the (total number of) degrees traversed by the Moon, together with the signs, having considered the desired measurement with these (conversions).

P: The (number of) *dvādaśāṃśas* traversed by the Sun are (equal to) the (number of) signs (traversed by) the Moon; to this *bhukti* of the Sun is added the *tithis* which have passed of the current month multiplied by 12. For one who is examining (the problem), this is the desired elongation between them.

Note: In other words, for each 1° traversed by the Sun, there are 12° of elongation of the Moon. The purpose of these two verses concern the calculation of sign which the Moon occupies in horoscopic calculation based on principle of elongation. Note here *rāśaiḥ* as an irregular form instead of *rāśibhiḥ*. The same is found in the next verse.

True motion of the Sun

N101r5
trayas trikṛt[A] ṣaḍguṇitās[B] tu bhāvyā[C] liptā dviṣaṣtis tv adhikās[D] tu rāśaiḥ[E] |
cakrārdhayor[F] māsam ataḥ sphuṭākhyaḥ[G] kramotkramābhyāṃ[H] ravir eti[I] rāśim ||23||

[A] °strikṛt]p_{ed}, °stṛvṛn N, °stṛvṛt ~~N~~$_p$ [B] ṣaḍgu°]p_{ed}, sadgu° N [C] bhāvyā]N, bhuktvā p_{ed}

[D] liptā dviṣaṣṭis tv adhi°]p_{ed}, liptādvisaptādvisaptatyadhi° N [E] rāśaiḥ]N, rāśeḥ ~~N~~$_p$ [F] cakrārdhayo°]p_{ed}, cakrārdhayo° N [G] °māsam ataḥ sphuṭākhyaḥ]emend, māsamaṣadvayākhyaḥ N_{pc}, māṣadvayākhyaḥ N_{ac}, mā(sama)dhavyayākhyaiḥ p_{ed} [H] kramotkra°]emend. ~~N~~$_{p}$, kramokra° N [I] ravir eti]p_{ed}, raviranti N

M: [At the rate of] (a minimum daily motion of) 57 minutes and a maximum of 62 minutes through the signs, in the two halves of the zodiac, the Sun, <u>called "true [motion]" (*sphuṭākhyaḥ*)</u>, goes through a sign <u>in a month (*māsa*)</u> in direct and reverse order respectively.

P: The Sun goes through each sign at a minimum daily motion of 57 minutes, and a maximum of 62. In the two halves of the zodiac, the Sun goes through a sign in more or less than a month in direct and reverse order respectively.

Note: The true daily motion of the Sun is given also in the PS 2.1 (*Vasiṣṭha*) and PS 3.17 (*Pauliśa*) but with possibly different numbers. Ideally, from apogee to perigee of the Sun, the degrees of solar motion for each of the six months should be: 57, 58, 59, 60, 61, 62; and the reverse for the other half. As the N's reading of 72 minutes is grossly out of range from the average of 1°, Pingree's emendation of pāda *b* is logical, although the placement of two *tu*-s is problematic gramatically. The motion here is described by Pingree as "linear zigzag function of ultimate Babylonian origin". Since the motion described here is true, there is no point in describing the duration as "more or less than a month" as Pingree did, which I emended instead to *sphuṭākhyaḥ* in parallel to v.25.

<u>True motion of the Moon</u>

N101r5-101v1

advyardhaliptāḥ[A] tricatuṣka[B] bhāge[C] +++ <sāmāpasu>tā catur<bhi>ḥ[D] |
saptatrayo[E] viṃśatibhāgayuktāṃ[F] pādādhikāṃ[G] pañcama ++++ ||24||

[A] advyardhaliptāḥ]N, indur hi liptāḥ p_{ed} [B] tricatuṣka]emend., satṛsapta N, śatasapta]p_{ed}
[C] bhāge]N, bhuktvā p_{ed} [D] +++<sāmāpasu>tācatur<bhi>ḥ]N, +++<?ā>sa+++catu+ p_{ed}
[E] saptatrayo]N, catustrayo p_{ed} [F] °yuktāṃ]N, °yuktāḥ p_{ed} [G] pādādhikāṃ]N, pādādhikāḥ p_{ed}

M: <u>[The Moon goes] 11°58,30' (12° less 1,30') (in its minimum daily motion, and...) by 4; 21,20°... plus a quarter...fifth...</u>

P: The Moon goes 700+ minutes (in its minimum daily motion, and … in its maximum); (the daily difference) is 0;12,20° +.

Note: As stated in v.22, since for each degree the Sun traverses, the Moon moves 12 degrees (or 720 minutes), which is expected to be the mean daily motion of the Moon. The minimum daily motion of the Moon is thus expected to be slightly less than the mean motion. The true motion of the Moon is also given in *Vasiṣṭhasiddhānta* 2.2-6; our verse appears to be too corrupt to do much meaningful comparison.

N101v1

<kra>motkramābhyāṃ prathamāntyabhuktiś[A] cakrārdhayor[B] bheṣu caran śaśāṅkaḥ |
bhuktir viliptāḥ[C] sakalāḥ sphuṭākhyāḥ svoccāṃśaliptās tv adhikaiḥ kalāṃśaiḥ ||25||

[A] °bhuktiś]p_{ed}, °bhājyaś N [B] cakrā°]p_{ed}, candrā° N, [C] bhuktirvi°]emend., bhuktivi° N

P: The Moon, passing through the signs in the two halves of the zodiac, travels at the first (minimum) and the last (maximum) rate of motion in direct and reverse order; thus it traverses all the accurate degrees, minutes, and seconds (between two successive conjunctions) with its apogee (*ucca*).

Note: Although no epicycles are evident or implicit in the expressions, the *ucca* is expressed here as point of reference where the Moon is the slowest.

True motion of the stars

N101v1-2

ādyantarāśyor udaya[A]pramāṇam ādyā muhūrtadvayam[B] ādiśanti |
kramotkramād apy adhipañcamaṃ tat kṣetrapramāṇaṃ bhagaṇadvayoḥ[C] syāt ||26||

[A] udaya°]~~N~~$_p$(emend.), udayaḥ N [B] muhūrta°]Np_{ed}, muhūrtā° ~~N~~$_p$ [C] bhagaṇadvayoḥ]N, bhagaṇadvaye p_{ed}

M: The ancients declare the measure of the rising-times of the first and last signs to be two *muhūrtas*; the space-measure (*kṣetrapramāṇam*) of the (rest of the) signs in the two (halves) of the zodiac, taken (respectively) in direct and reverse order, would be (obtained from) that with a fifth added (successively to each, that is, 24°).

P: The measure of the rising-times of the first and last signs the ancients demonstrate to be two *muhūrtas*; the measure in the (rest of the) signs in the two halves of the zodiac, taken (respectively) in direct and reverse order, is that (two *muhūrtas*) with a fifth added (successively to each).

Note: The difference in the rising-times of the different signs results from the difference between the right and oblique ascensions, which in turn depends on the latitude of observation. The conversion between the measure of rising-time (*udayapramāṇa*) and space-measure (*kṣetrapramāṇa*) would be as follows:

rāśi	*udayapramāṇa* (in *muhūrta*)	*kṣetrapramāṇa* (in *bhāga*)
meṣa / mīna	2	24
vṛṣabha / kumbha	2 ⅕	26;24
mithuna / makara	2 ⅖	28;48

karka / dhanvin	2 ⅗	31;12
siṃha / vṛścika	2 ⅘	33;36
kanyā / tulā	3	36
total	30	360

This verse corresponds to the description given earlier in YJ 1.68, which Pingree translated as "The measure of the rising-times of the first and last signs is demonstrated with certainty to be two *muhūrtas* each; know that the measure of the rising-times (of the rest of the signs) in the two halves of the zodiac, taken (respectively) in direct and reverse order, is (two *muhūrtas*) with a fifth (of that measure) added (successively to each)."[117] As Pingree pointed out, this "corresponds to a longest daylight of 13;26;24 hours, which is not bad for Ujjain".[118] Pingree pointed out an alternative interpretation of YJ 1.68 that if one reads the difference as ⅖ *muhūrta* instead of ⅕ *muhūrta*, then "one must understand a *muhūrta* to correspond to an equatorial arc of 10° so that there are 36 in a nychthemeron"; such interpretation is however grammatically impossible. Moreover, as clearly stated in v.29, there are 30 *muhūrtas* in a nychthemeron. Pingree's "alternative interpretation" is therefore not intended by the author here.

Water-clock

N101v2

dvābhyām atho[A] kāñcanamāṣakābhyāṃ[B] samāṃśakaṃ[C] dvyaṅgulatulyadīrghāḥ[D] |
chidraṃ tadagreṇa sameti yat syād vāryāḍhakaṃ saṃsthitināḍikā sā[E] ||27||

[A] <d>vābhyāmatho]N, ghaṭyāmatho p_{ed} [B] kāṃcanamāṣakābhyāṃ]N$_{pc}$, kāṃcanamaṣanakābhyāṃ N$_{ac}$, kāṃcamakābhyāṃ ~~N~~$_{ppc}$, kāṃcamanakābhyāṃ ~~N~~$_{pac}$, kāṃcana<lo>hakāyāṃ p_{ed} [C] samāṃśakaṃ]emend., samāṃsakā N, samāśakā ~~Np~~, syād vāṃśako p_{ed} [D] °dīrghāḥ]N, °dīrghaḥ p_{ed} [E] vāryāḍhakaṃsaṃsthitināịkāsā]emend., vārāthamānasthitināḍikāsā N, vāromānasthitināḍikāśā ~~N~~$_{p}$, vāri pramāṇe tithināḍikānām p_{ed}

M: <u>Now, if an *āḍhaka* of water enters into the hole [of the water-clock which was perforated] by the end of a [needle made] with equal proportion (*samāṃśakaṃ*) from two *māṣakas* of gold into a length of two *aṅgulas*, that is the duration of a *nāḍikā*.</u>

P: In a gold and metallic (*lohaka*) pot (*ghaṭī*) is a tube two fingers long; water enters a hole in front of this (tube) to measure off the *tithis* and *nāḍikā*-s.

Note: Despite some difficulties in the manuscript reading of this verse, the basic idea as described in the next verse is clear, namely, the complete outflow of water from the

[117] *ādyantarāśer udayapramāṇaṃ dvau dvau muhūrtau niyataṃ pradiṣṭau | kramotkramābhyām adhipañcamaṃ syāc cakrārdhayor viddhy udayapramāṇam ||*

[118] Pingree 1978a: II.228.

water-clock would last a *nāḍikā*, sixty of which make up one day which is typical in India.[119] The outflow water-clock was alluded to in the VJ but no description was given.[120] One of the earliest descriptions of an outflow water-clock is found in AŚ 2.20.34: “Forty *kalās* are a *nāḍikā*. Alternatively, a *nāḍikā* is an *āḍhaka* of water [passing through] a jar’s hole [of the width of a wire made] four *māṣakas* of gold [made into] the length of four *aṅgulas*.”[121] The description of the hole and the gold wire were identical to those of our verse, in particular, the weight-length ratio (1 *māsaka*:1 *aṅgula*) of the gold needle is identical in the two texts. The description of gold made into a wire of "equal proportion" (*samāṃśakaṃ*) or of uniform shape appears also in the Buddhist *Divyāvadāna*/ŚKA,[122] and Lalla’s description of a sinking bowl type water-clock.[123] Although the has been some doubt concerning the practicality of such description,[124] as well as how this water-clock actually operated, the resemblance of these highly specified

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[119] Although Pingree’s emendation and interpretation of this verse are strange to me, his understanding of this verse being a description of an outflow water clock should be correct (Pingree 1978a: II.410). As pointed out by Sarma, the outflow water clock was discarded and replaced by the sinking bowl type water clock from about fourth century CE (Sarma 2004: 302, fn.2).

[120] VJ(R)7, 17; VJ(Y)8, 24. Cf. Fleet 1915: 216.

[121] *catvāriṃśatkalā nāḍikā / suvarṇamāṣakāś catvāraś caturaṅgulāyāmāḥ kumbhacchiddram āḍhakam ambhaso vā nāḷikā.* According to Sarma, this is the first time a gold wire or needle was described for the measurement of the perforation of the water clock (Sarma 2004: 304; cf. Subbarayappa 2008: 180, Olivelle 2013:146).

[122] *nālikāchidrasya kiṃ pramāṇaṃ / suvarṇamātraṃ upari caturaṅgulā suvarṇaśalākā kartavyā / vṛttaparimaṇḍalā samantāc caturasrā āyatā* // ŚKA p. 57. "How does one measure the hole of the water clock (*nālikā-*)? With a measure of gold, a gold needle of four *aṅgulas* should be made. It [should be] stretched [so that it is] perfectly round from all sides and in four angles (?)."

[123] *daśabhiḥ śulbasya palaiḥ pātraṃ kalaśārdhasannibhaṃ ghaṭitam / hastārdhamukhavyāsaṃ samaghaṭavṛttaṃ dalocchrāyaṃ // satryaṃśamāṣakatrayakṛtanalayā samasavṛttayā hemnaḥ / caturaṅgulayā viddhaṃ majjati vimale jale nāḍyā //* “The bowl, which resembles half a pot (i.e. hemispherical), which is made of ten *palas* of copper, which is half a cubit (i.e. twelve *aṅgulas*) in diameter at the mouth and half (i.e. six *aṅgulas*) as high, which is evenly circular and which is bored by a uniformly circular needle, made of three and one-third *māṣas* of gold and of four *aṅgulas* in length, sinks into clear water in one *ghaṭikā* (*nāḍī*).” (*Śiṣyadhīvṛddhidatantra* 1.12, quoted in Sarma 2004:305, followed by Sarma’s translation, underline mine).

[124] The description of the gold wire later on became a tradition although its usefulness is doubtful based on Sarma’s study. “One is... led to suspect these specifications for the size of the perforation in terms of a gold wire of certain weight and length are fictitious and have no connection with actual practice.” (Sarma 2004: 306). The reason is that the size of the hole had to be calibrated depending on other factors such as shape of the vessel. Thus Bhāskara II considered the size of the hole as well as the volume of the vessel itself irrelevant (Sarma 2004: 306-307). However, one should note that the specification of this gold wire varies across texts and to my best of knowledge, only in the AŚ and in our text this particular correspondence is observed.

descriptions is remarkable. Sphujidhvaja must have derived his descriptions of the water-clock at least partially from Indian sources (see also next verse) although the outflow water-clock itself could well be of ultimately Babylonian origin.[125]

For the description concerning the water, the emendation of *vāryāḍhakaṃ* is necessary to specify the actual amount of water that flows out of the device in a *nāḍikā*. In pāda *d*, Pingree's emendation of *sthiti* to *tithi* is improbable since the water-clock had never been known to be used for the measurement of lunar time unit such as the *tithi*.

Time measures

N101v2-3
trayaḥ palāḥ[A] syuḥ kuḍavo ’ṣṭamaś ca tan nāḍikākhyaṃ[B] vidur ekaṣaṣṭim[C] |
sā[D] ṣaṣṭiliptāpi[E] ca nāḍikākhyāḥ[F] sravanti ṣaṣṭir[G] dyuniśā krameṇa ||28||

[A] palāḥ]p_{ed}, phalā N [B] °khyaṃ]~~N~~$_{p}$, °khya N [C] °ṣaṣṭim]p_{ed}, °ṣaṣṭiḥ N, °ṣaṣṭaḥ ~~N~~$_{p}$
[D] sā]emend. HAYASHI, tāḥ N [E] °liptāpi]p_{ed}, °liptau'pi N [F] °khyāḥ N, °khyā]p_{ed}
[G] sravanti ṣaṣṭir]emend., śravantiṣaṭca N, bhavanti ṣaṣṭir p_{ed}

N101v3
kalā[A] nimeṣāṣṭaśatā daśonā viduḥ kalās tā daśa[B] nāḍikās tu[C] |
dvināḍikas tu prathito muhūrto mānapramāṇādividhiprasiddhau ||29||

[A] kalā]p_{ed}, kālā N [B] kalāstā daśa°]s_{ed}, kalāstāraśa° N, kalās triṃśa <ca> p_{ed} [C] °kāstu]N, °kā tu ~~N~~$_{p}$

M: In [increasing] order: A *kuḍava* is 3⅛ *palas*; 61 *kuḍavas* are called 1 *nāḍikā*; it (*nāḍikā*) also consists of 60 *liptās*; 60 of what is called *nāḍikās* [of water] flow away [in the clepsydrae] in a nychthemeron. One *kalā* equals 790 *nimeṣas*, one *nāḍikā* 10 *kalās*, and one *muhūrta* is known as 2 *nāḍikās* in the accomplishment of the rules relating to measures and standards.

P: A *kuḍava* is 3⅛ *palas*, and 61 *kuḍavas* equal 1 *nāḍikā*. The *nāḍikās* are also each divided into 60 *liptās* ("minutes"); there are 60 *nāḍikās* in a nychthemeron. One *kalā* equals 790(?) *nimeṣas*, one *nāḍikā* 30 *kalās*, and one *muhūrta* 2 *nāḍikās* in the accomplishment of the rules relating to measures and standards.

Note: The conversion of time units may be summarized as follows: 3⅛ *palas* = 1 *kuḍava*; 61 *kuḍavas* = 60 *liptās* = 10 *kalās* = 1 *nāḍika*; 60 *nāḍikās* = 1 nychthemeron; 790 *nimeṣas* = 1 *kalā*; 2 *nāḍikās* = 1 *muhūrta*. In modern units by increasing order: *nimeṣa* ≃ 0.18",

[125] S.R. Sarma pointed out to me that the outflow type water clock was described with practical details only in Babylonian sources and not any Indian texts extant. The weight of the water used in a cylindrical clepsydra, together with the unique solstitial day-night ratio of 3:2 applicable to Mesopotamia and not so much to India except in the extreme north, were described in Old Babylonian mathematical tablets (Neugebauer 1947: 39-40).

pala 7.55", *kuḍava* ≃ 23.61", *liptā* 24", *kalā* 2'24", *nāḍikā* 24', *muhūrta* (or *kṣaṇa*, cf. verse 11-13) 48', *dyuniśā* (or *ahorātra*) 1 day or 24 hours. A comparison of the conversion of units among some key texts utilizing the same units was made in §III.4.1.

As pointed out in §III.2.3.2, the collection of units used in these two verses has so far not been attested elsewhere in any other single text, which once again suggests the amalgamated nature of the YJ. The *pala* and the *kuḍava* are noted in the VJ. The combination of *nimeṣa* and *kalā* is noted in a number of texts such as the *Suśrutasaṃhitā,*[126] the *Parāśara*,[127] the *Arthaśāstra*[128] and the *Amarakośa*[129] and various Purāṇic texts.[130] The combination of *nimeṣa*, *kalā* and *nāḍikā* is rather rare and is noted only in the AŚ, and possibly the VJ, if we take *nimeṣa* and *akṣara* as similar units.

It should be noted that *pala* and *kuḍava* are originally units for liquid measure.[131] They can be converted into time units only with the assumption of the use of a water-clock (v.27) as described in the VJ. The VJ prescribed that the time of the outflow of a *prastha* (or 12.5 *palas*) of water corresponds to the daily lengthening of daytime from the winter to the summer solstice.[132] In other words, in a solstitial period of 183 days, 183 *prasthas* (or 2287.5 *palas*) would correspond to 6 *muhūrtas* or 12 *nāḍikās*. This results in 1 *nāḍikā* = 190.625 *palas*, which corresponds to the conversion described in this verse.

The conversion of 1 *nāḍikā* = 10 *kalās*, which was read incorrectly by Pingree as 1 *nāḍikā* = 30 *kalās*, applies in fact elsewhere in this text (vv.11-13, 31). The same conversion is noted in the *Parāśara*. By extension, the conversion 1 *muhūrta* = 20 *kalā* is noted also in the *Suśrutasaṃhitā.*[133] Similar, but not identical conversion between *nāḍikā* and *kalā* may be found in the VJ.[134] Shukla suggested that Yavaneśvara/Sphujidhvaja had either followed *Suśruta*/*Parāśara* or rounded off the value from the VJ to avoid fraction.[135]

The conversion of 1 *kalā* = 790 *nimeṣas* is not attested anywhere. The normal conversion value one would expect is 1 *kalā* = 450 or 540 *nimeṣa* as Pingree pointed out.[136]

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126 *Suśrutasaṃhitā, Sūtrasthāna,* vi.4.

127 Utpala's commentary on BS 3.2, Dvivedi ed. p.23 ln 14.

128 *Arthaśāstra* 2.20.28-38.

129 *Nāmaliṅgānuśāsana* 1.3.11-12.

130 *Viṣṇupurāṇa* 1.3.8-10; *Vāyupurāṇa* 57.6-7; *Nāradīyamahāpurāṇa* 5.21-22.

131 Fleet 1915: 214-217, 222; Sarma 2004: 310.

132 Fleet 1915: 217; Shamasastry 1936: 1-2, 25; Sastry & Sarma 1984: 44.

133 The comparison was first noted in Shukla 1989: 213, although in the text itself the unit *nāḍikā* was not used and instead 1 *muhūrta* = 20 *kalā* was given.

134 1 *nāḍikā* = 201/20. VJ(R)16ab, VJ(Y)38ab: *kalā daśa saviṃśā syād dve muhūrtasya nāḍike*.

135 Shukla 1989: 213.

136 Pingree 1978a: II.410. The conversion of 1 *nāḍikā* = 7900 *nimeṣas* may be most closely compared to that

The *liptā* is a sexigesimal unit unknown to any other early Sanskrit work and the use of *liptā* as a time measure is rare. It was attested in the Bakhshālī manuscript but with a different conversion value (1 *ghaṭikā* = 60 *caṣaka* and 1 *caṣaka* = 60 *liptā*).[137] Following its Greek antecedent *λεπτόν*, the *liptā* is typically used as an angular measurement for the celestial sphere, as we have seen earlier in vv.23-28, namely 1 degree (*bhāga*) = 60 minutes (*liptā*) and 1 minute = 60 seconds (*viliptā*). The use of *liptā* as both time and angular measures is comparable, though not identical to our usage of the word "minute".

<u>**Course of the Sun**</u>

N101v3-4

raver udaṅmārgagatiṃ[A] mṛgādau yāmyāyanādiṃ tu caturthabhādau |
vindyād ajādau viṣuvantam[A] ādyam abde dvitīyaṃ <tu> tulādharādau ||30||

[A] udaṅmā°]~~N~~$_p$(emend.), udanmā° N [B] viṣuvantam]N(p_{ed}), viguvantam ~~N~~$_p$

P: One should find that the northern course of the Sun begins at the beginning of Capricorn, and the southern course at the beginning of the fourth sign (Cancer); the first equator(-crossing) in the year is at the beginning of Aries, the second at the beginning of Libra.

N101v4

raviḥ svamānena bhunakti[A] rāśīn tadvikrameṇāhnakṛd[B] iṣyate saḥ |
āhnā[C] dyurātreś ca phalānirastis[D] tribhāgahīno[E] 'yanayoḥ kalaikaḥ[F] ||31||

[A] bhunakti]p_{ed}, tubhukta° N, tubhukti ~~N~~$_p$ [B] °meṇāhnakṛ°]p_{ed}, °meṇantukṛ N, °meṇatrikṛ° ~~N~~$_p$
[C] āhnā]N, aho p_{ed} [D] phalānirastis]emend. HAYASHI, phalāniriṣṭas N, phalo niriṣṭas ~~N~~$_p$
[E] bhāgahīno]emend., bhāhīnā N, bhā<ga>hīno p_{ed} [F] kalaikaḥ]p_{ed}, kalaikāḥ N

M: The Sun, in its own measure, traverses the signs; because of this motion it is regarded as the cause of the day. <u>The daily gain (*phala*) and loss (*nirasti*) of a nychthemeron in the two (northward and southward) courses (of the Sun) (*ayanayoḥ*) is one *kalā* less one third (i.e., ⅔ *kalā*).</u>[138]

P: The Sun, in its own measure, traverses the signs; because of this motion it is regarded as the cause of the day. The length of daylight in a nyehthemeron (increases) and decreases in the two *ayanas* (i.e., while the Sun is between the two solstices) by a third part.

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of the *Viṣṇudharmottarapurāṇa*, namely 1 *nāḍikā* = 7200 *nimeṣas* (*Viṣṇudharmottarapurāṇa* 1.73.1-4ab).

137 Hayashi 1995: Table 12.1.

138 I owe the reading of pādas *cd* to Professor Takao Hayashi, who had furthermore noted the irregular lengthening of *phalā* metri causa (also *aṅgirāsaḥ* v.54b and *bhavā* v.57d).

Note: The time difference between the longest and shortest daylight is known to be 6 *muhūrtas*.[139] As indicated earlier in v.29, one *muhūrta* = 20 *kalās*. Therefore, in half a year or 180 days between the summer and winter solstices, the daily decrease of daylight time should be (6 × 20) ÷ 180 = ⅔ *kalā*. As noted by Shukla, the conversion of 1 *nāḍika* = 10 *kalā* here, which applies also to the calculation given in vv.11-13, provides another proof that Pingree's reading of 1 *nāḍikā* = 30 *kalās* in v.29 was incorrect.[140]

Gnomon

N101v4-5

ahaḥpramāṇārdhaguṇe 'sya[A] śaṅkoś chāyāṅgulair madhyadināṅgulonaiḥ |
saśāṅkavair[B] labdham ahaḥparaṃ[C] tad ahno viśuddhaṃ tv aparānhi[D] yāvat ||32||

[A] °guṇasya]p_{ed}, °guṇesya N [B] saśāṅkavair]p_{ed}, śaśāṅgavair N [C] mahaḥparaṃ]p_{ed}, mahatyatan N, mahapataṃ ~~N~~$_{p}$ [D] °parāhni]p_{ed}, °parāhna N

P: The gnomon (śaṅku) is multiplied by half the measure of daylight, (and is divided) by the digits of the shadow (at any given time) diminished by the digit of the noon (shadow) and increased by the gnomon. The result is the former part of the day; if you subtract it from the (total) length of daylight, that is how much is in the rest of the day.

Note: Cf. PS 4.48. Note the length of the gnomon is not given, but is generally assumed to be 12 *aṅgulas* as pointed out by Pingree.

Ascendent

N101v5

muhūrtabhāgair[A] udayaprasiddhir[B] jñeyo[C] gṛhāṃśādigaṇasya sūkṣmaḥ[D] |
sūryāśritād ṛkṣagaṇāt pravṛttaṃ[E] sayogyalagnokta[F]vidhiṃ vidadhyāt ||33||

[A] °bhāgair]~~N~~$_{p}$(emend.), °bhāger N [B] udayaprasiddhir ~~N~~$_{p}$(emend.), udayeprasiddhaiḥ N
[C] °jñeyo]~~N~~$_{p}$(emend.), ° jñeyā N [D] sūkṣmā p_{ed}, sūkṣma N [E] pravṛttiṃ]~~N~~$_{p}$(emend.), pravittiṃ N
[F] °nokta°]~~N~~$_{p}$(emend.), °noktam N (unmetrical)

P: The establishment of the ascendent, which is subtle (?) as consisting of signs, degrees, and so on, is to be known by means of the *muhūrtas* and their parts (which have passed of the day); one should establish the described rule regarding the ascendant which is to be used as beginning from the number of the sign occupied by the Sun.

Civil days in a solar year

N101v5

139 18−12, as standard in India, see Pingree 1978a: I.228, II.410.

140 Shukla 1989: 212.

sapañcaṣaṣṭiṃ triśataṃ[A] dinānāṃ[B] yugād vibhinnaṃ[C] tu dināṃśakānām |
tryūnaṃ[D] śatārdhaṃ dinakṛtsamā syād yayā bhavargaṃ savitā bhunakti ||34||

[A] °ṣaṣṭiṃ triśataṃ]$p_{ed}s_{ed}$, °ṣaṭkāttrisatī N, °°ṣaṭkā trisatī ~~N~~$_p$ [B] dinānāṃ°]$p_{ed}s_{ed}$, guṇānāṃ N

[C] yugād vi°]s_{ed}, yugādi° N, dyūnaṃ dvi° p_{ed} [D] tryūnaṃ]~~N~~$_p$(emend.)s_{ed}, tryūne N

M: <u>The solar year (*dinakṛtsamā*)</u> in which the sun traverses the constellations (*bhavarga*) consists of 365 days and <u>a fraction of a day, which equals forty seven (fifty minus three) divided by [the number of solar years in a] *yuga*.</u>[141]

P: A year of the Sun consists of 365 days and 14;47 sixtieths (aṃśas) of a day, in which the Sun traverses the signs.

Note: Assuming there are 365 civil days in a year, a *yuga* of 165 years would consist of 60225 civil days. The difference between this and the actual number of civil days in a *yuga* (v.7): 60272 − 60225 is 47 civil days. The fractional part may be obtained by dividing this by the number of years in a *yuga*, or 47/165 day. The number of days in a solar year given in YJ is hence nearly 365.2848.

Pingree's emendation in pāda *b*: *dyūnaṃ dvibhinnaṃ* to mean 14/60 is puzzling. As pointed out in §III.3/§III.4, his connection of this emended value to Hipparchus' value for the tropical year is untenable. The idea of tropical year, defined as the period of the Sun returning to an equinoctial point, entails the concept of precession which is nowhere evident in the YJ. The concept of solar year here is defined as the period of the Sun returning to a fixed point on the ecliptic, i.e., *meṣādi*, and is therefore equivalent to our sidereal year, whose modern value is nearly 365.25636 days.

<u>Sidereal and synodic periods of the planets</u>[142]

N101v5-102r1[143]

śataṃ saṣaṭpaṃcaka[A] ++++ triṃśad dvikaikottarikā[B] tathaikam[C] |
tripañcakāgraṃ ca śataṃ yugāni gurvārasauraindavabhārgavānām ||35||

[A] saṣaṭpaṃcaka]p_{ed}, saṭpañcaka N [B] triṃśad°]p_{ed}, dviṃkha° P, - K, - N

[C] tathaikam]p_{ed}, tathaikā N

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141 Following Shukla 1989.

142 At the time of the press, my reading of N_t from v.35 to v.56 (facsimile reproduced at the end of the article) remains most unsatisfactory and I have refrained from supplying in the apparatus any N reading in places where I was uncertain. I have supplied however readings from Q from v.45c. Many of Pingree's emendations appear doubtful and in particular, his *bhūtasaṃkhyā* readings in v.39 (*-ārka-* = 12) and v.40 (*śaśānḳa-*) are unlikely for reasons discussed in §III.2.1. A close examination of the planetary theory provided by these verses is a desideratum, with the hope that new manuscripts of better quality may turn up one day.

143 From v.35a-, missing in N_{bw} and N_c, available only in N_t.

P: 130, 32, 31, 1, and 115 ... the *yugas* of Jupiter, Mars, Saturn, Mercury, and Venus,

N102r1
śataṃ saviṃśad[A] daśa pañcakāgrās triṃśat trayaḥ ṣaṭtricatuṣkanighnāḥ |
svaiḥ svair yugābdair udayāḥ[B] syur eṣāṃ vitarkayārkād ubhayān[C] vadanti ||36||

[A] °saviṃśad]p_{ed}, saviṅsa N [B] udayāḥ]p_{ed}, udayā N [C] °dubhayān]emend., °dubhayo NKP, °d udayān p_{ed}

M: 120, 15, 30, 3, and 72 are their (heliacal) risings in the years of their own *yugas*; they say, consider <u>both</u> (calculated) from the Sun.

P: 120, 15, 30, 3, and 72 are their (heliacal) risings in the years of their own *yugas*; they say, consider the risings as being from the Sun.

Note: The periodicity as summarized by Pingree is as follows:

Planet	*Yuga*	Number of synodic periods	Synodic period
Saturn	31 years	30	377 days
Jupiter	130 years	120	395 days
Mars	32 years	15	779 days
Venus	115 years	72	583 days
Mercrury	1 year	3	122 days

<u>True motions of the planets</u>

N102r1-2
svaṃ svaṃ yugaṃ ṣaṣṭiśataṃ[A] trayoghnaṃ[B] gatodayaiḥ[C] svair udayā[D] + dvasā |
bhavargabhogoddhṛtaśeṣam eṣāṃ vidyād grahāṇāṃ[E] kramaśaḥ[F] kramastāt[G] ||37||

[A] ṣaṣṭiśataṃ]p_{ed}, ṣa<ṣṭa>+ta N, ṣaṣṭaśataṃ KP [B] trayoghnaṃ]p_{ed}, traya<ghn>o N, trayaghnaṃ KP [C] gatodayaiḥ]p_{ed}, dva++++, +++yaḥ K [D] svair udayā]p_{ed}, +++yā N, hyatādayaḥ P [E] vidyād grahāṇāṃ]p_{ed}, vidyādgahānāṅ N, viṇādgramasaḥ P [F] kramaśaḥ]p_{ed}, gramasaḥ NK, kramāsāt P [G] kramastāt]p_{ed}, kramāstāt N, kramasāt P(?)

P: … each its own *yuga* … 160 multiplied by 3 … the risings by its own past risings. One should know the remainder extracted from the traversing of the signs by the planets in order (?).

N102r2
yugān[A] tadabdeṣu daśadvikaṃ ca ṣaḍ ekahīnāś ca vaped aśītiḥ[B] |
atītam eṣāṃ svayugāvaśeṣaṃ[C] jñeyaṃ[D] yugaikaṃ[E] kramaśo grahāṇām ||38||

[A] yugān]NKP, yugāt p_{ed} [B] aśītiḥ]p_{ed}, aśīti N [C] °vaśeṣaṃ]p_{ed}, °vaṣeṣaṃ N
[D] jñeyaṃ]p_{ed}, +yaṃ N [E] yugaikaṃ]p_{ed}, yugekaṃ N

P: One should cut off 105 in its years from the *yuga*. The remainder of its *yuga* which has passed is to be known as the first *yuga* of each of the planets in order (?).

N102r2-3
ṣaṣṭyaiḥ[A] śataiḥ[B] ṣaḍguṇitais[C] tribhis tu ādityabhuktarkṣagaṇāṃśayuktam[D] |
hṛtaṃ pṛthak svair udayārkabhāgair labdhaṃ kramaghnaṃ[E] vidur udgamaṃ tu ||39||

[A] ṣaṣṭyaiḥ]p_{ed}, ṣaṣṭaiḥ NKP [B] śataiḥ]p_{ed}, gataiḥ N [C] ṣaḍguṇitais]p_{ed}, ṣaḍguṇitas N
[D] °bhuktarkṣagaṇāṃśayuktam]p_{ed}, °muktarkṣagaṇāṃkhayuktam P, -rkṣagaṇāṃśayuktam K,
+ktarkṣagaṇanāṃśayukta? N [E] °rlabdhaṃ krama°]p_{ed}, °rlavṛṭkrama° K

P: The sum of degrees in the signs traversed by the Sun is multiplied by 1,800 sixtieths and divided separately by its own *dvādaśāṃśas* (*arkabhāga*) and by those of the ascendant; the results, multiplied together, are its risings.

N102r3
ekādaśāṃśāṃś[A] caturāṃśabhuktyā[B] gatvā gurus tāṃś ca śaśāṅkabhuktyā[C] |
sthitvāṣṭakaṃ tatra daśaikayuktaṃ[D] daśāṃśabhuktaṃ samupaiti vakram ||40||

[A] °daśāṃśāṃś°]p_{ed}, °daśāṃśca NKP [B] °bhuktyā]p_{ed}, °bhuktya NP
[C] °bhuktyā]p_{ed}, °bhuktya P, - N [D] daśaikayuktaṃ]p_{ed}, daśāṃkhabhukte NP

P: Jupiter goes 11° plus 4° plus 1°; then it stands still, and then goes *vakra* for 8°; then 11° plus 10°;

Note: The *bhūtasaṃkhyā* expression *śaśāṅkabhuktyā* to mean one degree is strange.

N102r3
tato gurus tāṃś ca ṣaḍaṃśabhuktyā[A] gatvo<dayaṃ[B] saṃ>caraṇaṃ[C] prayāti |
bhaumas tu yāti dviśataṃ[D] saṣaṣṭiṃ[E] catustrikoṇena śatatrayeṇa[F] ||41||

[A] ṣaḍaṃśa°]p_{ed}, ṣaḍāṃśa° NKP [B] gatvo<dayaṃ>]p_{ed}, gatvā++ K, tatpaṃcatā P, -N
[C] caraṇaṃ]p_{ed}, caramaṃ NP [D] dviśataṃ]p_{ed}, dviśatī NKP [E] saṣaṣṭiṃ]p_{ed}, savastaṃ N,
savastāṃ K savastraṃ P [F] śatatrayeṇa]p_{ed}, satattrayeṇa NK, satatrayena P

P: ...then Jupiter goes 6;15° and comes to its (heliacal) rising. Mars goes 162° in 288 (*tithis*);

N102r3-4
sthitvāṃśakāṃs trīṃś caturaṃśabhuktyā saptādhikāṃ viṃśatim eti vakre |
tāṃs triṃśabhuktyā pratigamya[A] yāti dvātriṃśatiṃ[B] viṃśatim ardhaṣaṭ[C] ca ||42||

[A] pratigamya]p_{ed}, pratigaṇya NKP [B] dvātriṃśatiṃ]p_{ed}, dvātriṃśatāṃ NKP,
[C] viṃśatim ardhaṣaṭ]p_{ed}, viṅśati++++ N, viṅgatimarddhaṣaṭca P, - K

P: ...and stands still; then it goes in vakra 27° plus 3° plus 4°; and then, going forward, it progresses 32° plus 30° plus 20° plus 6;30°.

N102r4
gatvāṣṭavargeṇa catuṣkam ārkiḥ sadvādaśāgreṇa[A] śatena yāti |
vakre tad itvā ca śatena bhūyo[B] yāty aṣṭakaṃ[B] dvādaśabhāgabhuktyā ||43||
[A] °ḥ sadvādaśāgreṇa]p_{ed}, °stadvādaśagreṇa N, °stadvādaśāgreṇa KP [B] bhūyo]p_{ed}, bhūyāṃ N
[C] yāty aṣṭaṃ]p_{ed}, yatyaṣṭaka N, yatyaṣtakaṃ KP

P: Saturn goes 8;15° in 112 (*tithis*); then, in vakra, it goes 8° in 100 (*tithis*) more; (its total synodic are) is 12°.

N102r4-5
ṣaḍaṣṭakaghnaṃ[A] dviguṇāṣṭakena gatvāṣṭakena dviguṇāṣṭakaṃ ca |
ṣaḍbhiś caturghnais tad[B] upetya vakre dviraṣṭakena pratiyāti tac ca ||44||
[A] °ghnaṃ]p_{ed}, °ghnāṃ NKP [B] °ś caturghnais ta°]p_{ed}, ++gnetu...d N, °ścatughnasta° KP

P: Mercury goes 48° in 16 (*tithis*) and 16° in 8 (*tithis*); then it goes in vakra that in 24 (*tithis*); then it goes forward that in 16 (*tithis*);

N102r5, Q90r1[144]
tataś catuḥpañcakam etya[A] saumyo dvātriṃśatībhis[B] trica<tuṣkibhi>ś ca[C] |
śeṣeṇa prācyāparadarśane[D] tu jñena[E] tritaṅka[F] tribhir eva vādyam[G] ||45||[H]
[A] pañcakam etya]p_{ed}, °pañcama<ttaṃ>tya °pañcamatītya KP [B] dvātriṃśatībhis]p_{ed}, dvātriṃsatābhyān N, dvātriṃśakābhyāṃ KP [C] trica<tuṣkibhi>ś ca]emend. HAYASHI, <tri>++ N, ti...śca K, trica... P, trica<turthakai>ś ca p_{ed} [D] prācyāparadarśane]p_{ed}, yātyaṅgurudarśane N, yātyaṅgurudarśaṇe Q, yātyaṃgurudarśane KP [E] tena]NP, jena K, - Q
[F] tritaṅka]p_{ed}, tritadgaṃ NP, tritaṅgra Q [G] vādyam]p_{ed}, P codyam NK, <c>odyam Q
[H] 45]p_{ed}, 87 Q

P: then it goes 20° in 32 (*tithis*) and in 12 (*tithis*). Furthermore, there are two first visibilities (*darśana*) - one in the East and one in the West; therefore...

N102r5, Q90r1-2
śate 'ṣṭakāgre[A] 'rdhaśatādhike[B] dve gatvāṣṭavargeṇa śatadvayena |

[144] Reading from Q (f.90) is available from pāda *c* onward. The verse was numbered as eighty-seven. See remarks on numbering in Q in §II.1 and notes for v.62.

vakre 'ṣṭaṣaṭkeṇa[C]caturguṇaṃ[D] ṣaḍ gatvā dinān[E] tiṣṭhati pañca śukraḥ[F] ||46||[G]

[D] 'ṣṭakāgre]p_{ed}, 'ṣṭakāgro NQ [B] ° 'ṣṭakāgre 'rdhaśatā°]p_{ed}, °ṣṭakegrādhaśatā° KP, °ṣṭakogrādhaśatā° Q [C] 'ṣṭaṣaṭkeṇa]p_{ed}, ṣṭaśaṭkoṇa NQ [D] caturguṇaṃ]p_{ed}, caturguṇā NQKP [E] dinān]p_{ed}, dinā NQKP [F] pañcaśukraḥ]NPK, +++<?ḥ> Q [G] 46]p, 8<8> Q

P: Venus goes 258° in 208 (*tithis*); then it goes in *vakra* 24° in 48 *tithis*, and stands still for five days (= *tithis*);

N102r5-102v1, Q90r2-3
tān pañca<ṣa>ḍbhiḥ[A] pratigamya[B] ṣaṭkair[C] aṣṭābhir aṣṭau dviguṇaiś ca gatvā |
ṣaḍbhiś caran sapta bhunakti śeṣaṃ sūryopagāṃś cāṃśakam ekaṃ mātra[D] ||47||

[A] <ṣa>ḍbhiḥ]P, ṣaḍ°? K, +<?iḥ> Q [B] pratigamya]p_{ed}, prahigatya N, prahiśatya K, prahiṣajya P, +hiśatya Q [C] ṣaḍkair]PK, sadyur Q [D] sūryopagāṃścāṃśakamekaṃmātra]emend., sūryopagāṃścāṃśakameka<ma>+ Q, †sūryo++++++++kaṃ† K, †sūryyāpa+++++kamaṃtrya† P, sūryāpa +++++kam etya p_{ed}

P: then it goes forward those 5° in 36 *tithis*; then it goes 8° in 16 (*tithis*), and traverses the remainder, travelling (at the rate of) 7° in 6 (*tithis*) ...

Note (40-47): The eight verses give a linear planetary theory similar to that of the Babylonian cuneiform texts as noted by Pingree.[145] The resemblance between the model presented here and that of *Vasiṣṭhasiddhānta* as presented in the PS has also been noted.[146] Since Vasiṣṭha was indeed mentioned earlier in v.3, further comparative study may prove worthwhile to establish the possible connection between the two.

N102v1, Q90r3-4
eṣāṃ ca paṃcāṃśakavargabhuktyā[A] prāgantarākhyā[B] gṛhabhuktir[C] uktā |
ato dviraṃśābhyadhikādhikaṃ[D] syā<t>[E] cakradvayor arbhavadṛk ca bhuktiḥ[F] ||48||

[A] °vargabhuktyā]Np_{ed}, °varṇabhuktyā P, °vargabhuktya K, +<rga>bhuktyā Q
[B] prāgantarā°]p_{ed}, prāgantyarā° Q, prāgantṛ° K, prāgantri° P [C] gṛha°]P, °rgṛha° QK
[D] dviraṃ°]p_{ed}, dhira...N, dhiraṃ° QKP [E] °dhikaṃ syā<t>]KP(p_{ed}),°dhikasmāc Q
[F] ccakrārdvayorarbhavadṛkcabhuktiḥ]Q, †++payorarbhavadṛkṣabhuktiḥ† KP

P: These (planets) traversing of a sign together with a traversing of a varga of 5° is called a *pragāntara* (?); hence the traversing of a sign is...

N102v1-2, Q90r4
ataḥ pravāsodayacakracārā sthitikriyā[A]kena guṇakrameṇa |

145 Pingree 1959b: 282-284; 1978: II.411-413.

146 Neugebauer & Pingree 1970: I.10.

vidyād[B] grahāṇām ṛjuvaikṛtāni saṃkhyānadṛṣṭyā[C] caritāni samyak ||49||[D]

[A] °kriyā]KP, kriyo Q [B] vidyād]p_{ed}, vidyāṃ KPQ [C] °nadṛṣṭyā]NQ, °nadṛṣṭā K, °nadṛṣṇā P, °navṛddhyā p_{ed} [D] 49]p_{ed}, 91 Q

M: Therefore they go in a cycle of heliacal risings and settings together with their stations in accordance with their qualities; one should know that the courses of the planets are straight and otherwise by means of calculation and observation.[147]

P: Therefore they go in a cycle of heliacal risings and settings together with their stations in accordance with their qualities; one should know that the courses of the planets are straight and otherwise because of the "increase in number."

N102v2, Q90r4-5
śukro 'ṣṭabhāgāntara[A]saṃsthito 'rkād[B] ekādaśāṃśāntaritaś[C] ca jīvaḥ |
sandarśane pañcadaśāntarasthāḥ śeṣā dviṣaṭkāntaritaś ca somaḥ ||50||[D]

[A] śukro 'ṣṭabhā°]p_{ed}, śukreṣubhā° NQP, śukreṣabhā° K [B] saṃsthito 'rkād]p_{ed}, saṃsthite'rkke Q, °saṃ+++ K, °saṃsthitarkā P, -N [C] °dekā]p_{ed}, ekā NQKP [D] 50]p_{ed}, 92 Q

P: Venus is at first visible when it is 8° from the Sun; Jupiter when it is 11°; the Moon when it is 12°; and the rest when they are 15°.

N102v2, Q90r5-6
aprāptacārāḥ[A] pratilomavakrās[B] tadvakrabhasthāḥ pratipūrayanti |
ṛkṣāntacārā viṣahanti[C] vakraṃ[D] dīnādhikaṃ vakrajam uttamaṃ tu[E] ||51||[F]

[A] °cārāḥ]K, °cāra P, °cāraṃ Q [B] pratiloma°]p_{ed}, pratilamba°Q, pratilamba° KP
[C] ṛkṣāntacārā viṣa]p_{ed}, ukṣāntacārādviṣa KPQ [D] vakraṃ]p_{ed}, vaktrā K, vaktrād P, vakrān Q [E] °muttamaṃ tu]K, °muttaraṃtu P, °muttarantra Q [F] 51]p_{ed}, 93 Q

P: (First) they lose their motions, then they retrograde in the reverse direction; then, staying in the sign (i.e., arc) of their retrogression, they fill out (the retrogression). Until they come to the end of that sign (arc), they endure retrogression. They become extremely distressed because of the retrogression.

Lord of the days and seasons

N102v2-3, Q90r6-7
sūryendubhaumaindavajīvaśukra[A]saurāḥ krameṇāhnaniśādhipāḥ syuḥ[B] |
abdādhipās tv ādiṣu ye 'dhipāś ca[C] tadabdapādyās tv ṛtupā ṛtūnām[D] ||52||[E]

[A] °maindava°PK, mendava Q [B] °hnaniśādhipāḥ syuḥ]p_{ed}, °haṇinartapāḥ syuḥ P, °bdanivarttayā+ K, °bdaninantapā syuḥ Q [C] ye 'dhipāś ca]emend., yādhipādyās QKP, ye 'dhipāḥ syus p_{ed}

[147] As Hayashi has pointed out to me, *saṃkhyāna* (calculation) is different from *saṃkhyā* (number).

[D] °s tv ṛtupā ṛtūnām]p_{ed}, °stṛtupādṛterka K, °stṛtupādṛtarkāt P, °stṛtupādṛterkān Q [E] 52]p_{ed}, 94 Q

P: The lords of the nychthemera are, in order, the Sun, the Moon, Mars, Mercury, Jupiter, Venus, and Saturn; the lords of the year are (the planets) which are lords on the first days (of the years); and the lords of the seasons (*ṛtu*) are the lords of the first days in those seasons during that year.

Computation of the planetary weekday

N102v3, Q90r7-8

upān vidhānāś ca[A] samas tithīnāṃ[B] gaṇas[C] tadabdāvamarātrihīnaḥ[D] |
yad uktasaptagrahabhaktiśiṣṭaṃ[E] tadabdapādigrahavāsaraṃ[F] tat ||53||[G]

[A] †upān vidhānā<ś ca>†]p_{ed}, upān vidhānā KQ, upācidhānā P [B] samas ti°]p_{ed}, samāti° KPQ [C] gaṇas]N, guṇas KP, guṇās Q [D] °dāvamarātrihīnaḥ]p_{ed}, °dāvamarātrihīnāt KP, °dāmavarātrihīnāt Q [E] °bhuktiśiṣṭaṃ]emend. HAYASHI, °bhuktimiṣṭaṃ Q, °bhakta° K, °bhakti° P, °bhaktam iṣṭaṃ p_{ed} [F] °vāsaraṃ]p_{ed}, vāsataṃ KPQ [G] 53]p_{ed}, 95 Q

M: The number of *tithis* minus the *avamarātris* in that year is equal to (the number of civil days); this number is divided by the seven planets and the remainder is counted from the lord of that year; the remainder from the division (*-bhaktiśiṣṭa*) (of this number) by the seven planets mentioned is (the indicator of) the planetary weekday which begins from the lord of that year.

P: The number of *tithis* minus the *avamarātris* in that year is equal to (the number of civil days); this number is divided by the seven planets and the remainder is counted from the lord of that year; (the result) is the planetary week-day (with which the next year begins).

Note: In commenting on a similar formulation given in the SS, Burgess pointed out that, "it is not correct to speak of the week at all in connection with India, for the Hindus do not seem ever to have regarded it as a division of time, or a period to be reckoned by; they knew only of a certain order of succession, in which the days were placed under the regency of the seven planets."[148] However, among the different assignments of lordship, only the seven-day week has a fixed recurring order and it is thus natural to turn seven days as a single concept and thus implicitly, a unit. The mathematical derivation of planetary weekday based on the apparent velocity of the planets was known to Āryabhaṭa (see notes to v.55).

The missing syllable in pāda *a* in all manuscripts suggests that NKPQ all ultimately descended from one corrupted source.

[148] Burgess 1858: 177; also, 176-178, 396.

Lord of the year, ayana and months

N102v4, Q90r8-9

ravīndujārkikṣitisūnuśukra[A]candrāṅgirāsaḥ kramaśo 'bdapāḥ[B] syuḥ |
māsādhipān viddhy[C] ayaneśvarau[D] tu nityaṃ ravīndū[E] paṭhitau[F] samāyām[G] ||54||[H]

[A] kṣitisūnuśukra°]P, °kṣisūnuśukra° K, °kṣitisūnuśukraś Q [B] °rāsaḥ kramaśo 'bdapāḥ]p_{ed}, °raujārkramaśobdamā K, °rojārkasasābdamā P, °rojāvasaṃsābdamā Q [C] māsādhipānviddhy]emend., māsādhipāviddhy PK, māsādhipānvidhy° Q [D] ayaneśvarau]PK, ayanaiśvaro Q [E] ravīndū]p_{ed}, ravīndo KPQ [F] paṭhitau]KQ, pathitau P [G] samāyām]p_{ed}, samāyāt KP, samā<yāt> Q [H] 54]p_{ed}, 96 Q

M: The lords of the years are in order the Sun, Mercury, Saturn, Mars, Venus, the Moon, and Jupiter; know that they are the lords of the months. Know that the two lords of the *ayanas* in a year are always said to be the Sun and the Moon.

P: The lords of the years are in order the Sun, Mercury, Saturn, Mars, Venus, the Moon, and Jupiter; they are also the lords of the months. Know that the two lords of the *ayanas* in a year are always said to be the Sun and the Moon.

Lord of the hours

N102v4, Q90r9-10, BhIII.16[149]

ādityaśukraindava[A]candrasaura[B]jīvāvaneyāḥ syur aharniśāsu[C] |
horeśvarās taddivasādhipādi[D]krameṇa tās tatra[E] caturguṇāḥ ṣaṭ ||55||[F]

[A] °raindava°]KP, °rendava° NQ, °renduja° Bh [B] °candrasaura°]KBh, vakrasaurāḥ N, °candrasaurā° Q, vakrasaura P [C] °harniśāsu]Bh, °<ho>nniśāsu N_{pc}, °henniśāsu N_{ac}P?, °hairnniśāsu Q, °hentiśāsu K(P?), °horniśāsu p_{ed} [D] °sādhipādi]Bh, °sādhipāni N, °sādhipāṇi Q, °sādhiyāni P, °sādipānāṃ Kp_{ed} [E] tāstatra]Bh, nāstattra NQ, nāstatu K, †nāste†tu Pp_{ed} [F] 55]p_{ed}, 97 Q

M: The lords of the hours (*horeśvarās*) in the nychthemera are [in the recursive order of] the Sun, Venus, Mercury, the Moon, Saturn, Jupiter, and Mars; by the order starting from the lords of the day of that [day], these would be the twenty-four lords of the hours in that [day].

P: The lords of the hours in the nychthemera are the Sun, Venus, Mercury, the Moon, Saturn, Jupiter, and Mars; (if they are put in groups of) 24, (the first ones) are in the order of the lords of the days.

Note: The derivation of the lords of the hour is given here is based on the lords of the weekday established in v.53. However, the underlying principle is the opposite. The order

[149] Shukla ed. 1976: 295.

of the lords of the hours here is in fact a rearrangement based on the apparent velocity of the planets, from Saturn being the slowest and ends with the Moon being the closest. The proper derivation was known to Indian astronomers since at least the time Āryabhaṭa (b. 476 CE).[150] The shift was made to coincide with the planetary week which begins with the Sun instead of Saturn. The principle is well known also to the classical authors such Cassius Dio (150-235 CE).[151] According to Neugebauer, the Greek origin is apparent "because it supposes a division of the day into 24 hours, a form of reckoning which is...a Hellenistic product of ultimately Egyptian origin".[152] *Horā*, derived most likely from *ὥρα*, was not commonly understood as a time division (1/24 of a day) in India,[153] but its relevance to time measurement was known to Bhāskara, who commented on Āryabhaṭīya III.16.[154] This verse from the YJ was quoted also by Bhāskara who attributed it to "Sphujidhvaja-yavaneśvara".[155]

Line of the transmission

N102v4-5, Q90r10-11; BhIII.17

prajāḥ sisṛkṣuḥ[A] kila[B] viśvadhātā prajāpatiḥ prāgvratam ācacāra[C] |
sa dvādaśāṃśa[D]prabhavāt svadehāc[E] chīrṣād[F] ito vai bhagaṇaṃ sasarja ||56||[G]

[A] sisṛkṣuḥ]Bhp_{ed}, śvi++ N, svisṛkṣuḥ KP, sthisṛrkṣuḥ Q [B] kila]PQBh, ++ NK
[C] °mācacāra]NPQBh, °māvacāra K [D] sa dvādaśāṃśa]emend., sarvādaśāṃśa° KPQ, sarvādṛśāṃśa° p_{ed}, sa dvādaśāṅga° Bh [E] °bhavātsvadehāc]NQK, °bhavāstvadehāc° P, °bhavaṃ svadehaṃ Bh [F] cchīṣād]NKP, cchīhād Q, sṛṣṭvād° Bh [G] 56]p_{ed}, 98 Q

M: The creator of all things, Prajāpati, desiring to create people, carried out his previous vow; <u>from his own twelve-part body he created the constellations beginning with its head.</u>

P: The creator of all things, Prajāpati, desiring to create people, carried out his previous vow; he created the constellations from his own body, beginning with the head - his body which is the source of parts which are like all things.

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150 *Saptaite horeśāḥ śanaiścarādyā yathākramaṃ śīghrāḥ | śīghrakramāc caturthā bhavanti sūryodayād dinapāḥ* (*Āryabhaṭīya* III.16, Shukla ed.). "These seven 'Lords of the Hour', beginning with Saturn, are [enumerated] in the order of its speed [from slow to fast]. In the order of swiftness, [every] fourth becomes the 'Lord of the Day' which begins from Sunrise". See also Yano 2003: 381.

151 Ideler 1825: 178ff.

152 Neugebauer 1969: 70.

153 Burgess 1858: 176-8.

154 Bhāskara's commentary to *Āryabhaṭīya Kālakriyāpāda* v.16 (Shukla ed. p.215): *evam ahorātre caturviṃśatikālahorāḥ*.

155 See discussion in §III.2.2.

Note: Yano pointed out to me that Bhāskara's quote was not known to Pingree. I have here taken largely Bhāskara's reading, with the exception that I retained the reading *aṃśa* which is often used in this text in the sense of "part", instead of the more common term *aṅga*. The description of the "twelve-part" zodiacal man is appropriate here.

N102v5; Q90r11-v1; BhIII.17
tebhyaḥ sa meṣādigaṇān[A] prajajñe tebhyaś ca tadbheda[B]vikalpato 'nyān[C] |
ato bhavargasya vidhiṃ[D] pravede[E] prajābhavābhāvavid īśvaratvam[F] ||57||[G]

[A] gaṇān]PBh, ganān NQK, gaṇaṃ p_{ed} [B] tadbheda°]NQKBhp_{ed}, tadgada° P [C] vikalpato 'nyān]Bh, vikalpate 'nyān Bh_{BC}, vikalpanānyāt NQ, vikalpanā syāt KP [D] vidhiṃ]KP, vidhiḥ NQ, vihuḥ Bh [E] pravede]NQPK, praṇetā Bh, prṇītye Bh_{ABC} [F] °dīśvaratvam]NQKp_{ed}, °dīśvaraś ca P, °dhīśvaratvam Bh [G] 57]p_{ed}, 99 Q

M. From these [bodily parts] he produced the group which begins with Aries; and from these (zodiacal signs) he [produced] other [finer divisions] which are derived based on their differences (i.e., *horā*, *drekkāṇa* and so on). Hence, one who knows the existence (*bhava*) and the origin (*bhāva*) of people, knew the rule of constellations, namely the lordship (*īśvaratvam*).

P. From these he produced the group which begins with Aries; and from these (zodiacal signs) are there distinction and differentiation between those (*material objects*). Hence the lord (*īśvara*) who knows the origin (*bhava*) and the existence (*bhāva*) of people, knew the rule of the zodiacal signs (i.e., astrology).

N102v5-103r1; Q90v1-2
saśīta[A]gharmāṃśugatiḥ[B] praṇeyā[C] bhūtākhyapañcagrahayogabhāgaḥ[D] |
evaṃ prajā[E]sthityudayavyayākhyo[F] viśvātmako[G] 'yaṃ vihito 'vikalpaḥ ||58||[H]

[A] saśīta°]Q, sasīta° NK, saṣeva° Pp_{ed} [B] °gharmāṃśugatiḥ]emend., °gharmāṅśugati° Q, °gharmānsugati° PK, °gharmānsugat+ N [C] praṇeyā]emend., praṇeyo NQ
[D] bhūtā<hayo>gabhā<gaḥ>°]Q, bhūtā... N [E] evaṃprajā°]Q, +<va>prajā° N, paṃcaśa° ~~N~~$_{p}$, <saṃ>pannasa°ṃ p_{ed}, [F] udayavyayākhyo]emend., udayāyasākhyo NQ, udayo yamākhyo p_{ed}
[G] viśvātmako]NQ, viśvātmiko p_{ed} [H] 58]p_{ed}, 100 Q

M: The motion of the Moon and the Sun is to be fixed. There is [also] a portion made up of the [various] combinations of five planets which are known as the [evil] spirits (*bhūta-*); in such a way the All-Soul (*viśvātmaka*) which is known as the sustenance, creation and destruction of beings is proclaimed to be undifferentiated.

P: He who obeys good conduct observed the dharmas ..., obtaining endurance and success with the name Yama he is established as the unvarying soul of the universe.

Note: Indeed as Pingree himself remarked, his emendation of *yamākhyo* would lead a very odd identification of Yama with viśvātmika Prajāpati. Though there is some uncertainty regarding the reconstruction of pāda *b*, this verse appears to be simply a continuation of the mythologization of all celestial objects which started from v.56.

N103r1; Q90v2-3
tapobhir ugradvibhir[A] aśvinau tu prāvāpatuḥ[B] śāstram idaṃ yato 'rkāt[C] |
ato 'śvayugbhāg vidadhau[D] vidhātā[E] śīrṣādi [F]kālarkṣaśarīracakraṃ[G] ||59||[H]

[A] ugradvibhir]NQ, ugrebhir N_s, ugrair vidur P [B] prāvāpatuḥ]emend. ISAACSON, pravāpratuḥ N, pravāpatuḥ ~~N_p~~, prakāśataḥ N_s, pravāya+ḥ Q, prajāpateḥ Pp_{ed}
[C] <rkāt>]Q, tkāt N, ṅkāt Ns, rkāt ~~N_p~~, 'rkaḥ p_{ed} [D] śvayugbhāgvidadhau]QN, śvayugbhākvidadhau N_s, 'śvayugmaṃ vidhau p_{ed} [E] vidhātā]Qp_{ed}, vidadhātā N [F] śīrṣādi]Q$N_s p_{ed}$, śīrṣodi N
[G] cakraṃ]QN, cakre p_{ed} [H] 59]p_{ed}, 101 Q

M: Since the Ashvins obtained this treatise with terrible doubles *tapas* from the Sun, therefore, the creator arranged the corporeal circle of asterisms which is *Kāla* with the head and so on, of which the [first] part is the pair of horses (*Aśvinī*).

P: By terrible feats of asceticism the two Aśvins learned this science from Prajāpati, and the Sun learned it from them; hence the Creator placed the pair of horses (*Aśvinī*) at the beginning of his head in the circle of signs which is the body of Kāla.

Note: The fact that the twin Aśvins were featured also in the legendary transmission of Āyurvedic knowledge from Prajāpati appears to have led Pingree to emend *pravāpatuḥ* (ms. *pravāpratuḥ*) to *prajāpateḥ,* associating Sphujidhvaja's source with Prajāpati which was mentioned earlier in v.56.[156] However, v.56 simply identifies Prajāpati as the primordial zodiacal man and not as part of the line of transmission. What this verse does is simply to realign the nakṣatras to the new equinoctial point associated with Aries since the early centuries of the common era.[157] Earlier in Ch.73, the "twenty-eight" nakṣatras were enumerated starting from Kṛttikā, and pādas *ab* serve to justify the shift.

The reference to double tapas is unknown.

Last three verses

N103r1-2; Q90v3-4
iti svabhāṣāracanā[A]tiguptād[B] viṣṇugraheśendumayāvatārāt[C] |
maharṣimukhyair[D] anudṛṣṭatattvād dhorārtha[E]ratnākaravāksamudrāt[F] ||60||[G]

[156] Pingree 1978a: II.414-415.

[157] Pingree in his commentary suggested that "Aśvinī already begins at Aries 0° in *Paitāmahasiddhānta* (summarized in *Pañcasiddhāntikā* 12), whose epoch is A.D. 80". One should take note that epochs are often created retrospectively.

[A] °racanā°]Qp_{ed}, °racaṇā° N, °varaṇā° N_s [B] °bhiguptād]emend., °bhiguptā N, °bhiguptā Q, °bhiguptāṃ $N_s p_{ed}$, [C] viṣṇugraheśendumayāvatārāt]emend. YOKOCHI, viṣṇugraharkṣāṅśumato 'vatārāt emend. MAK viṣṇugrahakṣ<ā>ṅsu++++<rā>t N, viṣṇugraha+... N_s, viṣṇugraha<kṣe>++tāvatārāt Q, viṣṇugraha†kṣe... p_{ed} [D] maharṣimukhyair]emend. ISAACSON, <ma>ha?i<m>ukhyair N, mahar<?i>mukhyair Q, ... N_p, mahīpamukhyair p_{ed}
[E] °tattvād dho°]=°tattvāt h<o>° QN, °tattvāṃ ho° p_{ed} [F] °samudrāt]emend. ISAACSON N_s, °samudrā QN, °samudrām p_{ed} [G] 60]p_{ed}, 102 Q

N103r2; Q90v4
sūryaprasādāgatatattvadṛṣṭir[A] lokānubhāvāya vacobhir ādyaiḥ |
idaṃ babhāṣe niravadyavākyo[B] horārthaśāstraṃ[C] yavaneśvaraḥ prāk ||61||[D]

[A] sūryaprasādāgatatattvadṛṣṭir]p_{ed}, sūryapraśādāgatatattvadṛṣṭir Q, sūryaprasā+gatatvadṛṣṭir° N, sudhāprasā+nvitatatvadṛṣṭiḥ° N_s [B] °vākyo]NQ, °vaktro N_s [C] horārthaśāstraṃ]p_{ed}, horārthasāstra N, horārthaśāstra Q [D] 61]p_{ed}, 103 Q

M: In the past the lord of the Greeks (*yavaneśvara*), whose vision of truth came from the grace of the Sun, whose sentences are blameless, from the ocean of words which is a jewel-mine of horoscopy, [whose meaning] was guarded (-*abhigupta*) by reason of being composed in its own language (*svabhāṣā-*), whose truth was revealed successively by the foremost of great sages, which descended from Viṣṇu, the Lord of the planets (*graheśa-*, i.e. the Sun), the Moon and Maya, taught this treatise of horoscopy in excellent words for the benefit of the world.

P: Previously Yavanesvara (the lord of the Greeks), whose vision of the truth came by favor of the Sun and whose language is flawless, translated this ocean of words, this jewel-mine of horoscopy, which was guarded by its being written in his tongue (i.e., Greek), but the truth of which was seen by the foremost of kings (in the year) 71; (he translated) this science of genethlialogy for the instruction of the world by means of excellent words.

Note: For the problem of Pingree's *bhūtasaṃkhyā* reading of v.60, see discussion in §III.2.1. The possible readings of the broken *akṣara* at the end of the compound in N are: *kṣā*/*rkṣā*/*kṣe*/*rkṣe*. The important point here overlooked by Pingree is that the expression does not end at the expression *viṣṇugraha-* as hinted by this broken *akṣara*. The final member of the compound *-avatārāt* provided by Q appears to be reliable and it removes the possibility of a *bhūtasaṃkhyā* reading. Furthermore, it points to the line of transmission of the text which is later echoed in v.62c. While my emendation appears to follow closer to the manuscript readings, Yokochi proposed the emendation *viṣṇugraheśendumayāvatārāt* which mirrors the expression in v.62c -- *nārāyaṇārkendumayādi*. If Yokochi's emendation is correct, the repetitiousness appears to me rather odd, but not impossible if one concedes that v.62 after all was an accretion.

Pingree's emendation *samudrām* in v.60d is unlikely since *samudra* is always masculine. The ablative reading was first suggested by Shastri (1897) and independently proposed by Isaacson who pointed to me that the string of ablative *bahuvrīhis* is desirable given the context. *Svabhāṣā* may refer to the foreign (non-Sanskrit) nature of the source of the materials found throughout the YJ, and thus the meaning was guarded or concealed.[158] But it does not necessarily refer to an immediate Greek exemplar for the YJ or entail the existence of such work. It should be noted that Yavaneśvara and Sphujidhvaja refer most likely to the same person and not two as Shastri, Kane and Pingree had assumed (§III.2.2).

Another indication that vv. 60-62 might have been inserted at a later age is that Sphujidhvaja was described in third person, *sphujidhvajo nāma babhūva rājā* (v.62a). This practice is comparable to that of the *Vedāṅgajyotiṣa* where the anonymous first person author (as in our text, v.1) attributed the work to Lagadha.[159] Finally, whoever the author of these verses was, as Sanderson pointed out to me, "it is surprising that the original text that formed the source of Yavaneśvara's should have been thought both to be in Greek and revealed/promulgated by Viṣṇu, etc." While Pingree would have assumed these idioms were haphazardly adopted by Sphujidhvaja in the process of Sanskritization, as far as the structure and many details of contents are concerned, the text gives the impression of being composed originally in Sanskrit, following a preexistent Indian tradition where Sanskrit *jyotiṣa* idioms were freely and comfortably used.

N103r2-3; Q90v5
sphujidhvajo[A] nāma babhūva rājā ya indravajrābhir idaṃ cakāra |
nārāyaṇārkendumayādidṛṣṭaṃ[B] kṛtsnaṃ[C] caturbhir matimāṃ[D] sahasraiḥ ||62||

[A] sphujidhvajo]NQ, sphūrjjidhvajo N$_s$ [B] nārāyaṇārkendumayādidṛṣṭaṃ]emend., nārāyaṇārkendumayādidṛṣṭāṃ Q, nārāyaṇā<rke>ndumayādidṛṣṭām N, nārāyaṇāṅkendumayādidṛṣṭaṃ ~~N~~$_p$, nārāyaṇāṅkendumayādidṛsṭvā N$_s$, nārāyaṇārkīndumeṣādidṛṣṭaṃ emend. FALK 2007:143 fn2, nārāyaṇāṅkendumitābdadṛṣṭaṃ *p*$_{ed}$ [C] kṛtsnaṃ]*p*$_{ed}$, kṛtsnāñ Q, kṛtsvāñ N, kṛtvā N$_s$
[D] matimāṃ]QN, matimān N$_s$*p*$_{ed}$

M: There was a wise king named Sphujidhvaja who composed this entire (text), which was beheld (-*dṛṣṭaṃ*) by Viṣṇu, the Sun, the Moon and Maya and so on, in 4,000 indravajrā verses.

P: There was a king named Sphujidhvaja who, being wise, versified this entire (text), which was seen by him in the year 191, in 4,000 indravajrā verses.

Note: The problem of Pingree's emendation of this verse and his *bhūtasaṃkhyā* reading

158 Vasudeva suggested to me *atiguptād* as a possible emendation, meaning "exceedingly obscure".

159 *kālajñānaṃ pravakṣyāmi lagadhasya mahātmanaḥ* (VJ-R 2cd).

of 191 (Śaka) years was discussed in §III.2.1. As for Falk's emendation *nārāyaṇārkīndumeṣādidṛṣṭaṃ* and his interpretation of an astronomical configuration, namely conjunction of Sun, Saturn, Moon at the beginning of Aries, the proposal is audacious but unlikely. Not only is it not supported by the mss., it is also unmetrical. Given the Q's reading of *-avatārāt* in v.60b, this compound most likely refers once again to the line of transmission.

The two compounds in v.60b and v.62c have led us to speculate on the possibility of four astronomical schools which must have been known to Sphujidhvaja. However, Soma has not been referred to in any *jyotiṣa* text known to me, while references to Viṣṇu (*Viṣṇusiddhānta*), Sūrya (*Sūryasiddhānta*) and Maya are well attested.[160] Maya is in particular noteworthy since it is mentioned also in the very beginning of the closely related VYJ.[161] In the SS, the body of heavenly knowledge was allegedly transmitted from the Sun also to the asura Maya (SS 1-9), who has been speculated to be a reference to Ptolemy by scholars such as Weber and Burgess on the basis of forms such as *Turamaya* found in some inscriptional sources.[162]

Regarding the reference to 4,000 *indravajrā* verses, the total count of verses of the work (both N and Q) is only around 2,207 (Pingree' edition). It seems rather unlikely such a sizeable portion of the work has gone missing when all the major topics seem to have been presented in their entirety when compared to the VYJ of around 8,000 verses. We do not know how seriously we should take this verse given a number of quirks which cannot be fully accounted for at present, namely, the inconsistency in narrative style, the wrong identification of meter and the redundant description of the line of transmission (§III.2.3.3).

Colophon

iti[A] yavanajātake[B] horā parisamāptā[C] // upendravajrāvṛtta[D] //[E]

[A] iti]emend., iti //O// N, iti //104// Q, - N_s [B] °jātake]NQ, °jataka N_s [C] horā parisamāptaḥ]emend., horoparisamāptaḥ Q, ho++++māptaḥ N, de+++parisamāptaḥ N_s, ho<rāvidhiḥ> samāptaḥ p_{ed}
[D] upendravajrāvṛtta]Q, upendravajrāvṛtta++++++++// N [E] additional line in Q: īsvarāya namaḥ / umāmahesvarābhyāṃ namaḥ // kta cta ṭta tta pta yta śta ke khe ge ghe ānaṃdamūrttaye namaḥ

M: Thus in the Yavanajātaka, the (chapter of) horoscopy is completed.

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160 Or alternatively, my emendation "descendant from Viṣṇu, the planets, the *nakṣatras* and the Moon" is somewhat closer to the manuscript reading.

161 "The sage of the past spoke this horoscopic treatise measuring in one hundred thousand (*lakṣamitam*) [verses] to Maya. Mīnarāja considered it with his own intelligence and cleverly made it into eight thousand [verses]". *yad uktavān pūrvamunis tu śāstraṃ horām ayaṃ lakṣamitaṃ mayāya | tan mīnarājo nipuṇaṃ svabuddhyā vicintya cakre 'ṣṭasahasramātram* || VYJ 1.2.

162 Weber 1853: 243, 1876: 270-271; Burgess 1858: 147.

P: In the Yavanajātaka: the rules relating to horoscopy are completed.

Note: The chapter, described simply as "horā", ends here.[163] As remarked in the introduction, Q grouped this chapter together with the two preceding chapters, making the number of verses 104 in total instead of 101 as Pingree counted (21 + 18 + 62). Unfortunately, in our present copy of Q, two pages are missing;[164] as a result the missing three verses in the preceding chapters cannot be accounted for and we cannot tell whether they belong to this mathematical section or the ones before. The last *upendravajrāvṛtta* found in both N and Q was probably an insertion by a learned scribe who noted that the verses were in the *upendravajrā* meter instead of *indravajrā* as they were incorrectly described in v.62. The final obeisance to *Umā* and *Maheśvara* in Q, followed by a curious alphabetical mantra associated with a certain *Ānandamūrti* revealing the phonetic knowledge (*śikṣā*) of the scribe, suggests at least one of its owners could be a follower of the Śaiva sect. Similar formulae of homage in different handwritings may be noted in N103v also. Further studies may reveal further background of the text and its transmission.

163 Pingree's emendation *horāvidhiḥ* was not reported by Shastri when N was presumably in a better state (Shastri 1911: 5-6). Q reads simply *yavanajātake horā parisamāptaḥ*.

164 ff.88-89 = Pingree ed. 78.14c-79.45b.

Abbreviations of Texts

AŚ	*Arthaśāstra* by Kauṭilya
BJ	*Bṛhajjātaka* by Varāhamihira
BS	*Bṛhatsaṃhitā* by Varāhamihira
PS	*Pañcasiddhāntikā* by Varāhamihira
ŚKA	*Śārdūlakarṇāvadāna*
SS	*Sūryasiddhānta*
T	*Taishō Tripiṭaka* 大正新脩大藏經
VJ	*Vedāṅgajyotiṣa* by Lagadha
VYJ	*Vṛddhayavanajātaka* by Mīnarāja
YJ	*Yavanajātaka* by Sphujidhvaja

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Appendix

Manuscript Q (NGMPP A 1122/3)

Q90r	YJ 79.45c
Q90v	YJ 79.57c

Manuscript N (NGMPP A 31/16; Tucci 13 (XLIX.21-38) / 34 (ex35) (XLII.1-9))

N_{bw}100r / N_c100r(a-c)	YJ 78.9a
N_{bw}100v / N_c100v(a-c)	YJ 79.2d
N_{bw}101r / N_c101r(a-c)	YJ 79.13b
N_{bw}101v / N_c101v(a-c)	YJ 79.24b
N_t102r / N_t102r(a-c)	YJ 79.35a
N_t102v / N_t102v(a-c)	YJ 79.47a
N_{bw}103r / N_c103r(a-c)	YJ 79.58b
N_{bw}103v(a-c)	backcover
N_c103v(a-c)	backcover

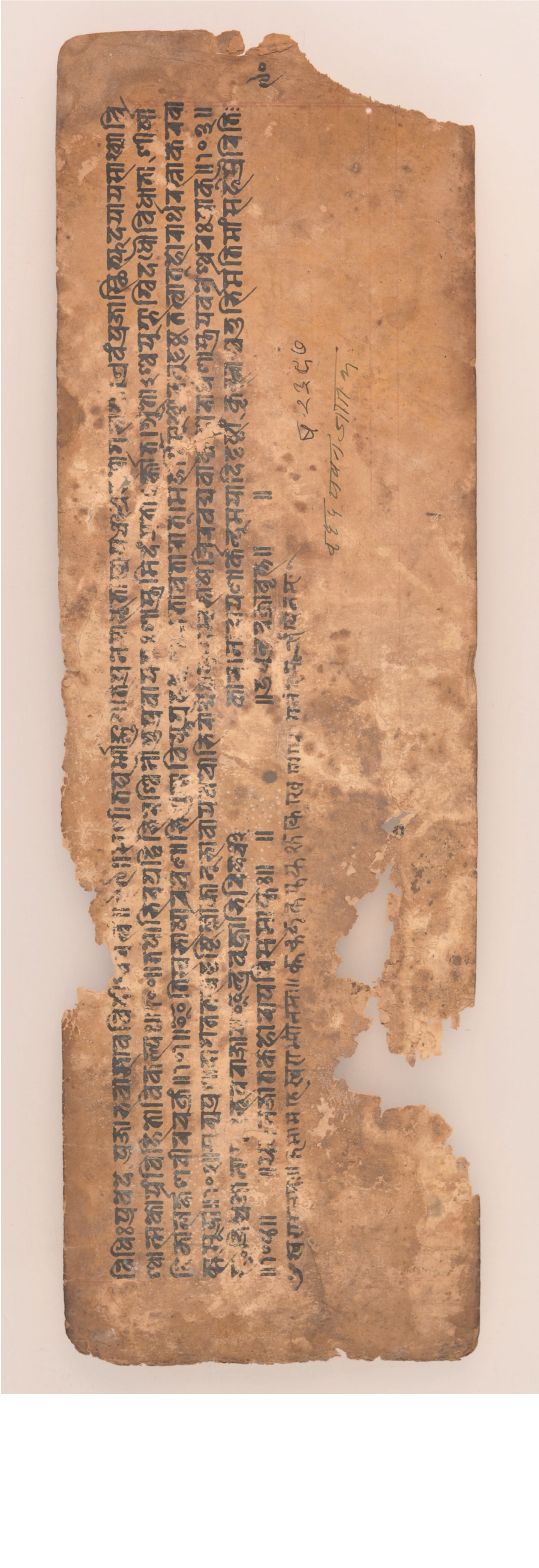
Manuscript Q

NGMPP A 1122/3

incipit: ...ṣena yātyaṅ gurudarśane + + + tritaṅgratribhir eva <vā>dyaṃ ||87|| (= N 79.45cd; Pingree 1978 I: 502)

Q90r

incipit: vidhiḥ pravede prajābhavābhavavid ī<śva>ratvaṃ ||99|| (= N 79.57cd; Pingree 1978 I: 504)

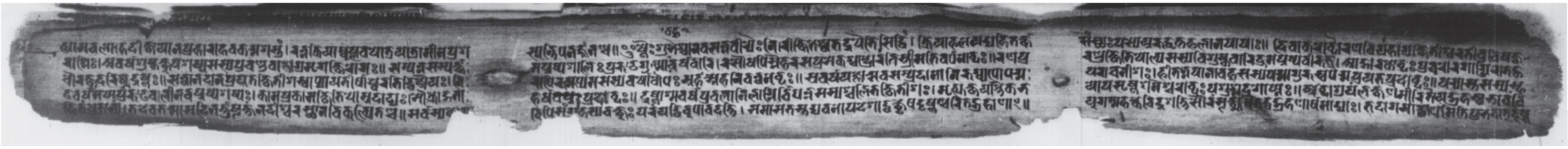


Q90v

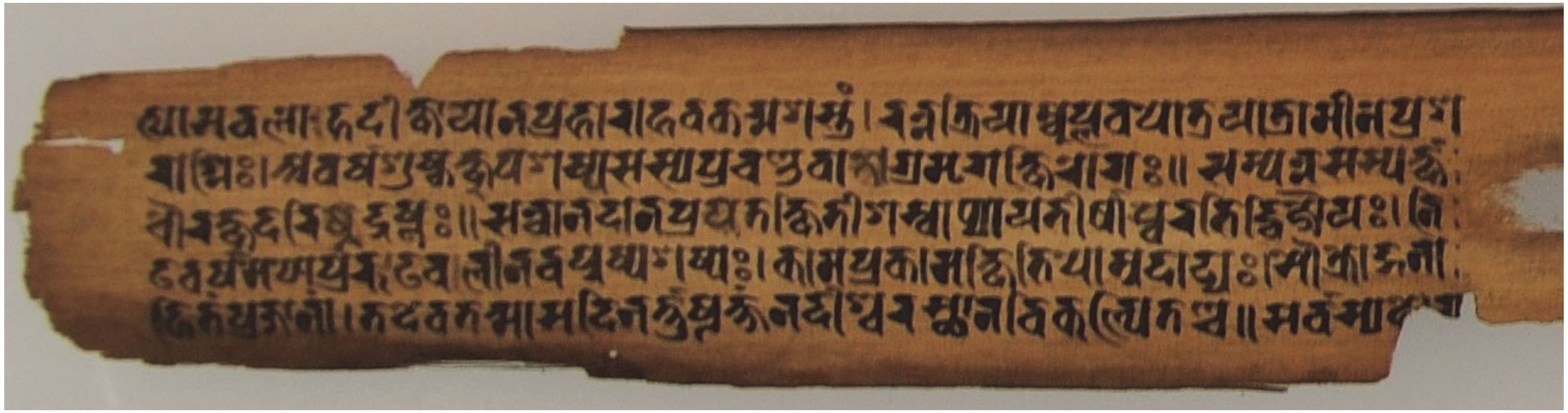
Manuscript N

NGMPP A 31/16

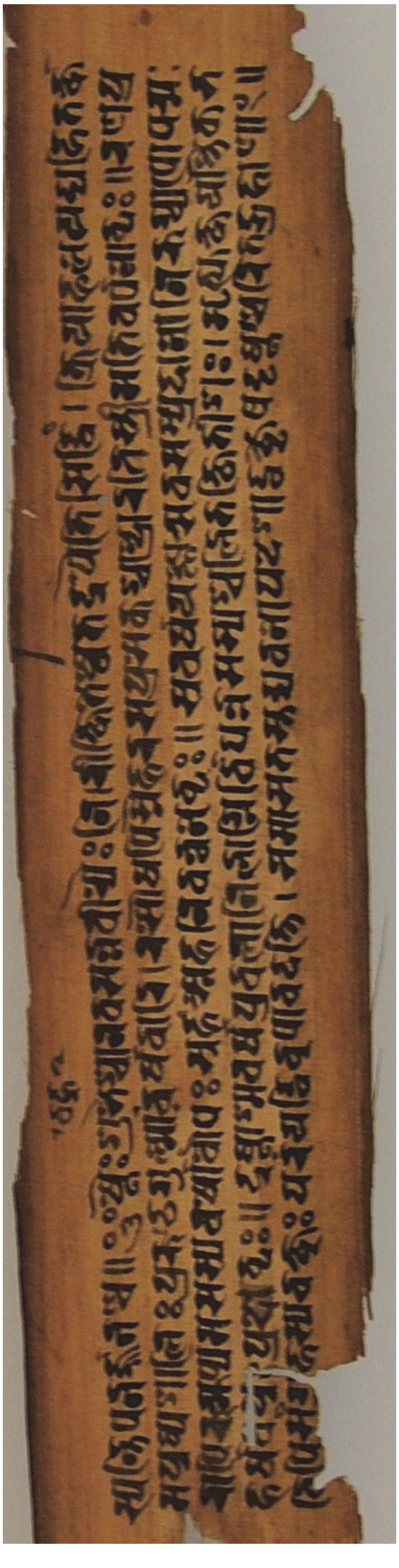
incipit: [kumbhe tu bhṛ]tyāsavalohadīkṣāyānaprahārāhavakarmaśastraṃ | (78.9ab; Pingree 1978 I: 491)



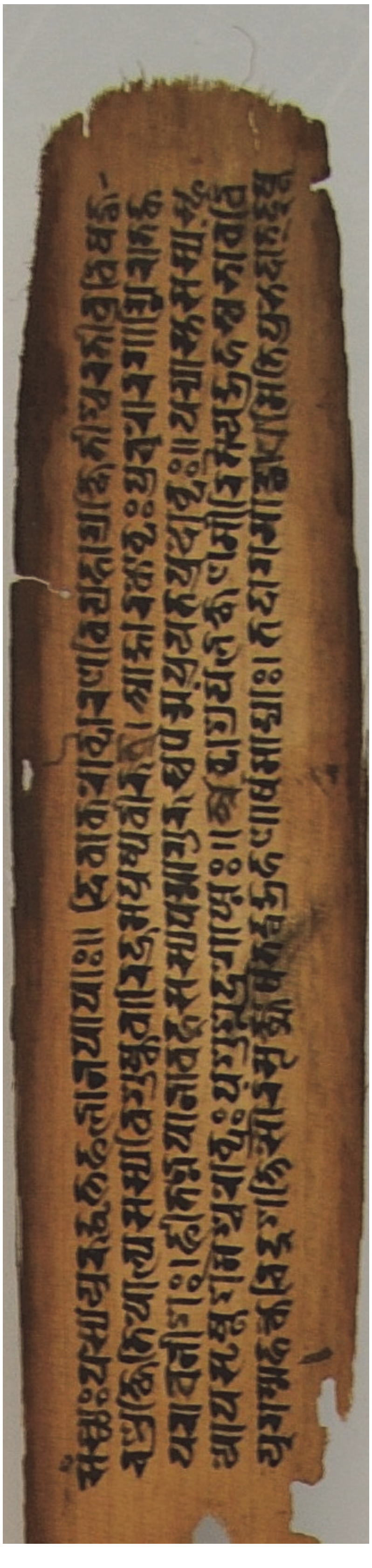
N_{bw}100r (exposure 104b)



N_c100r(a)

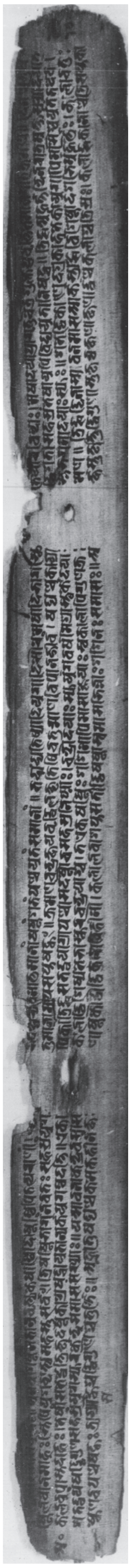


N_c100r(b)

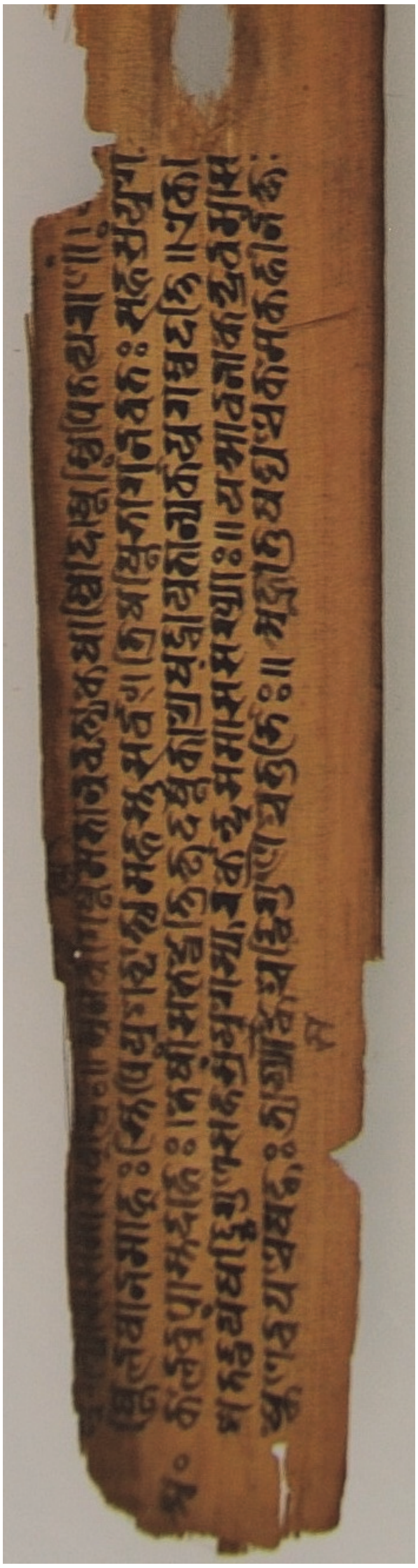


N_c100r(c)

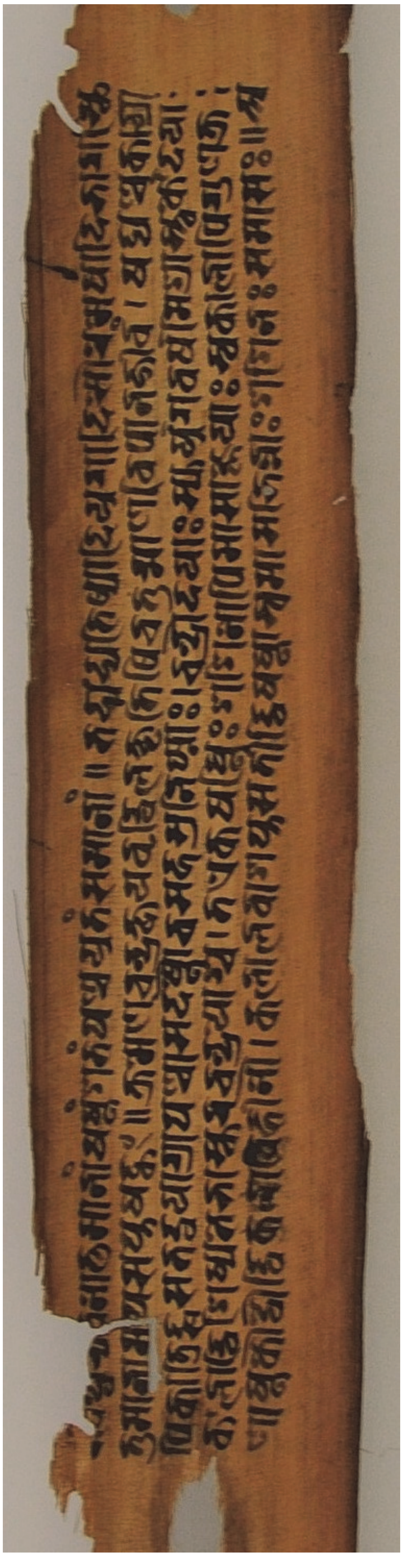
incipit: [duṣṭa]<ṣugatyāsa>samāsabuddhiḥ (79.2d; Pingree 1978 I: 494)



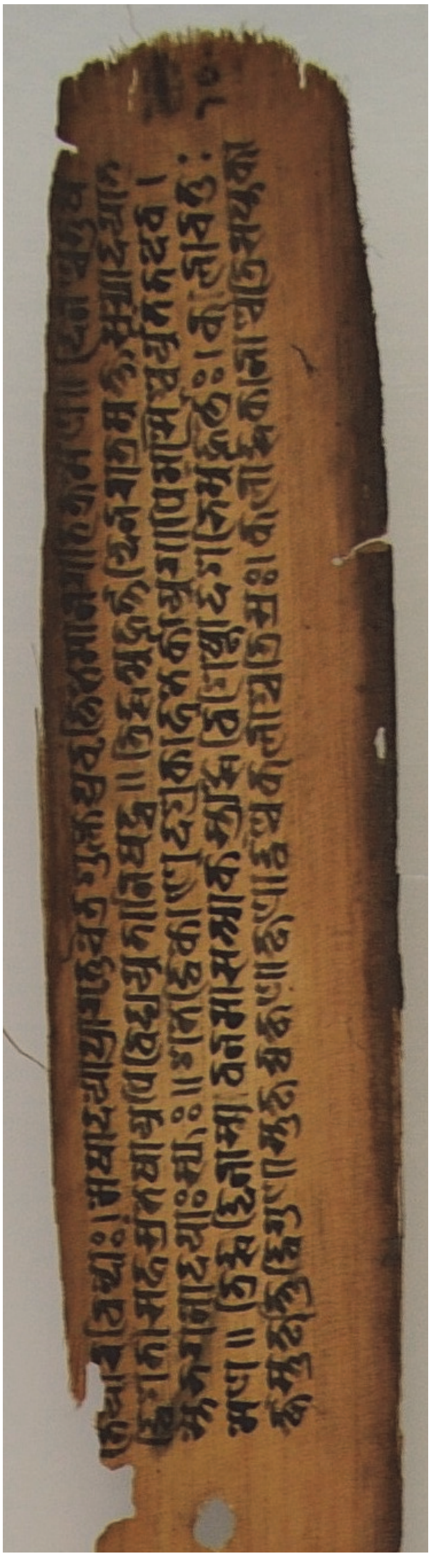
N_{bw}100v (exposure 105a)



N_c100v(a)

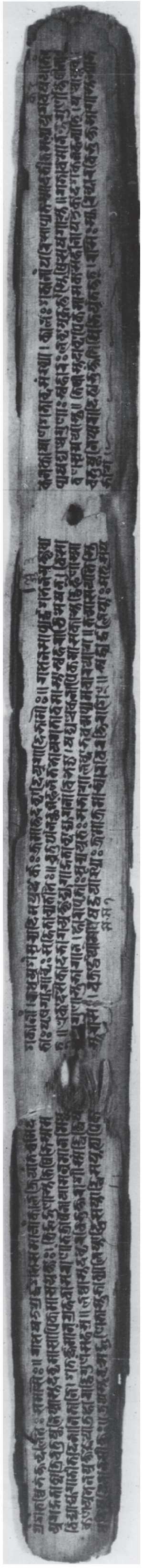


N_c100v(b)

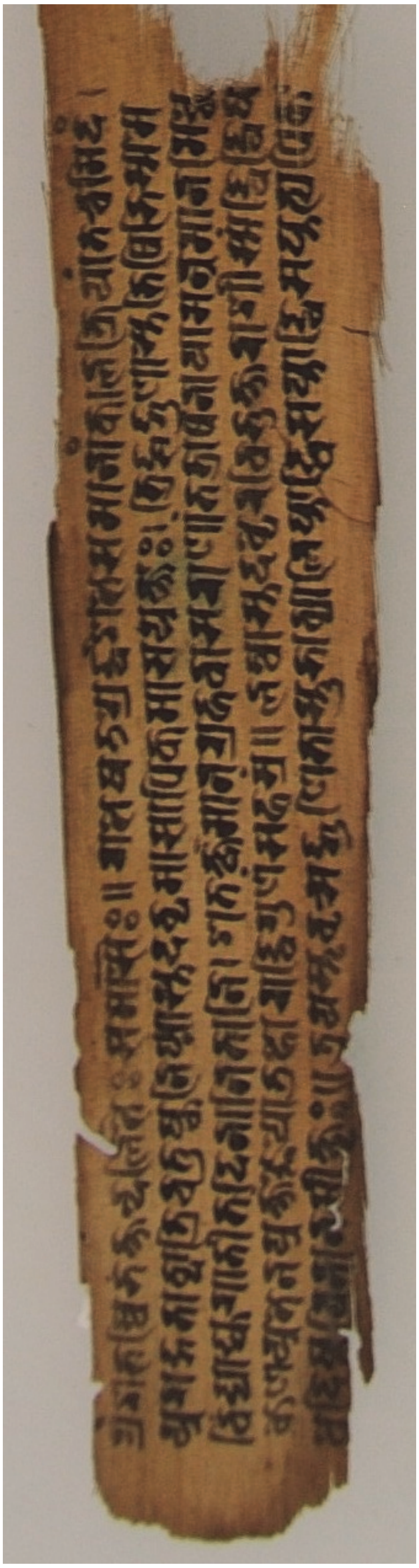


N_c100v(c)

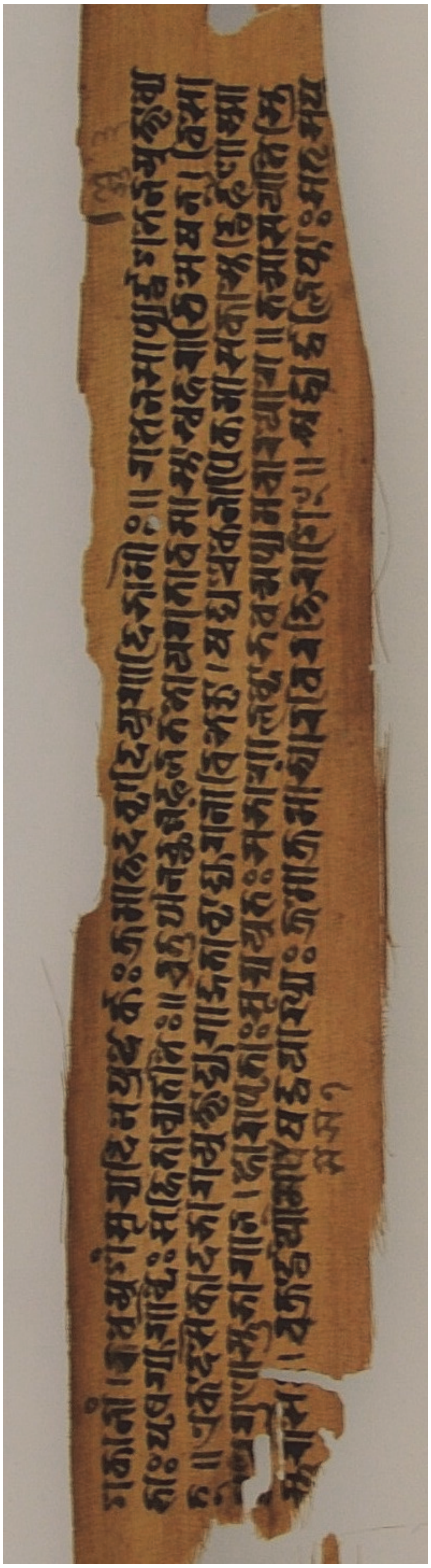
incipit: [kalāṃśakānāṃ ca trisaptakā]graṃ śataṃ vibhaktaṃ dalitaiḥ samāsaiḥ || (79.13bcd; Pingree 1978 I: 496)



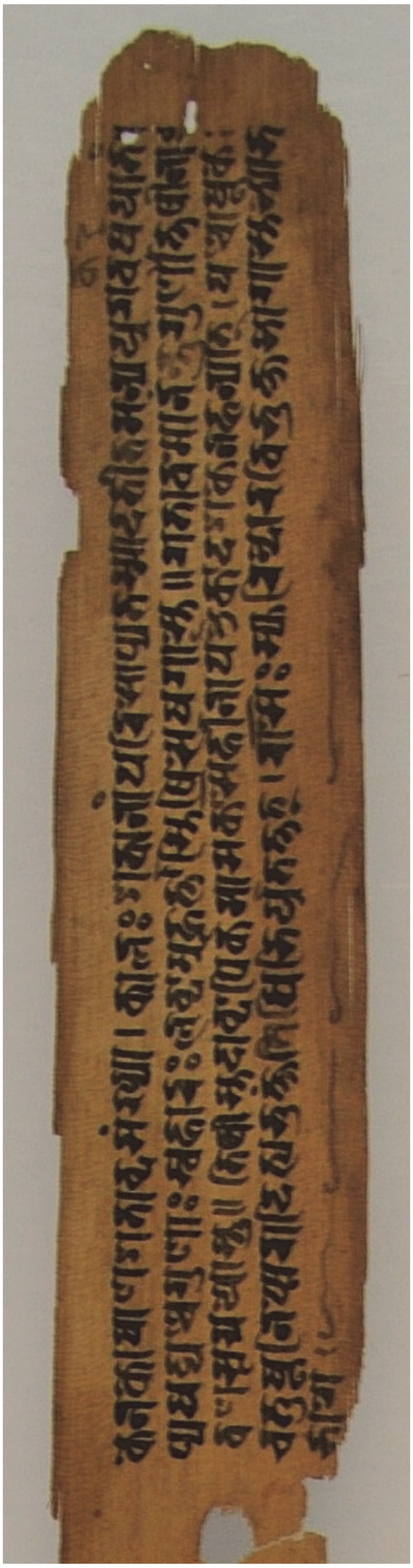
N_{bw}101r (exposure 106a)



N_c101r(a)

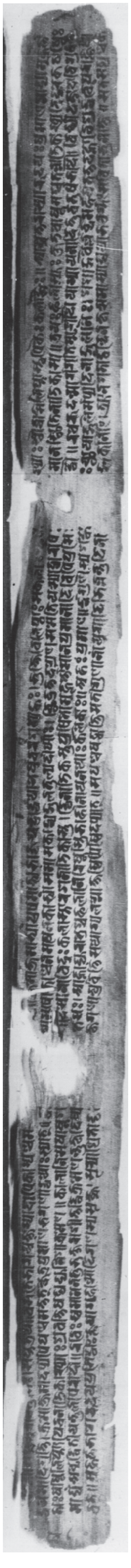


N_c101r(b)

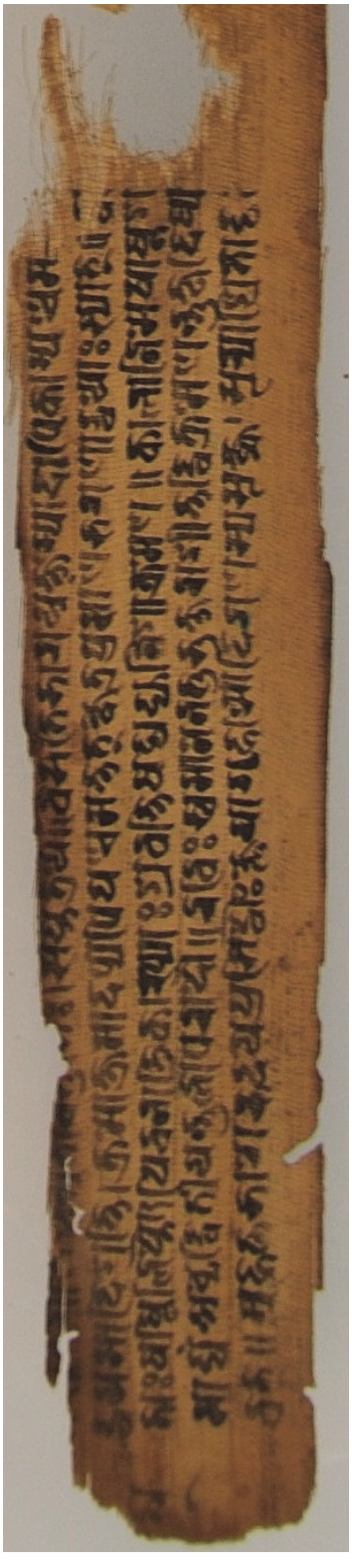


N_c101r(c)

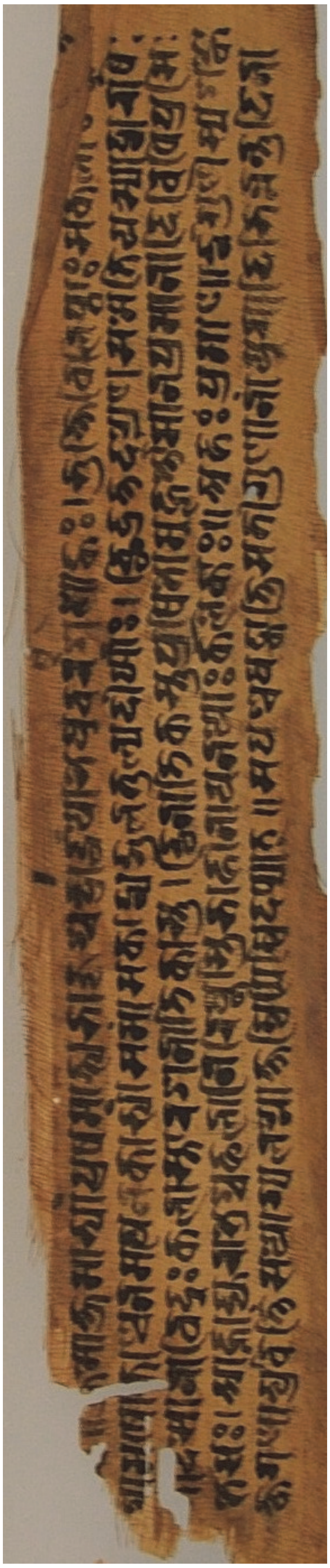
incipit: +++ <sāmāpasu>tā catur<bhi>ḥ | (79.24b; Pingree 1978 I: 498)



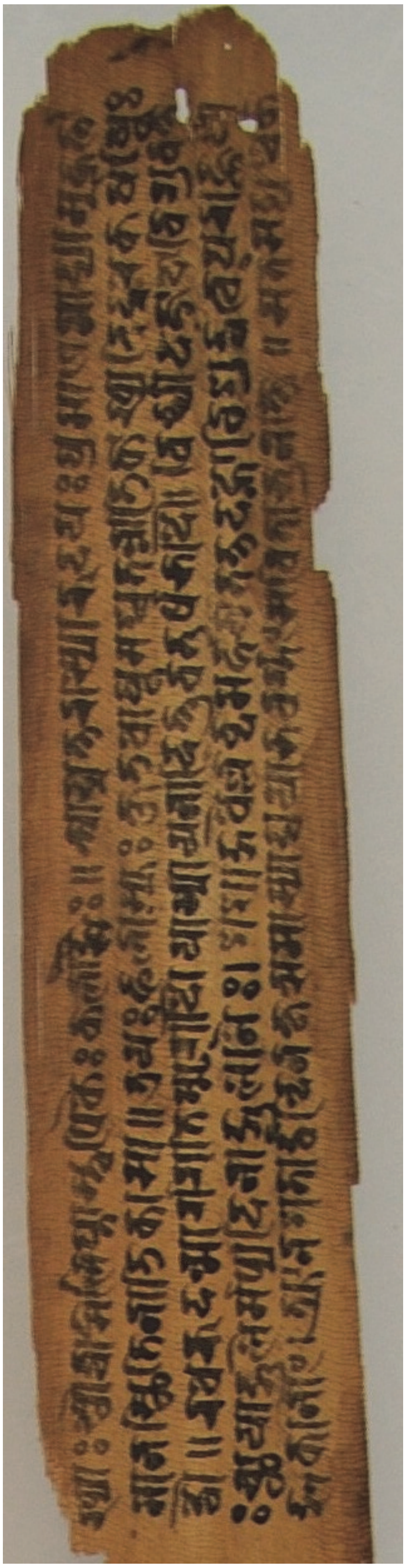
N_{bw}101v (exposure 105b)



N_{c}101v(a)

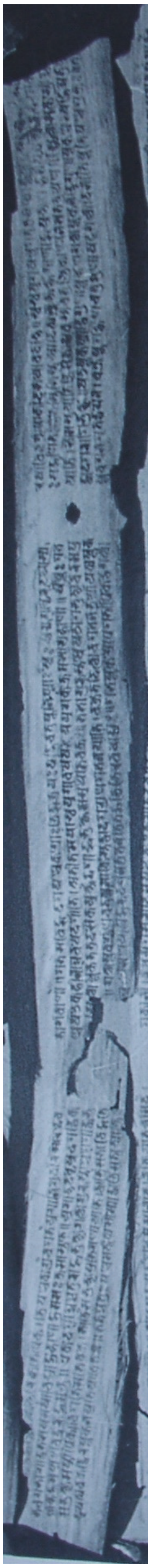


N_c101v(b)

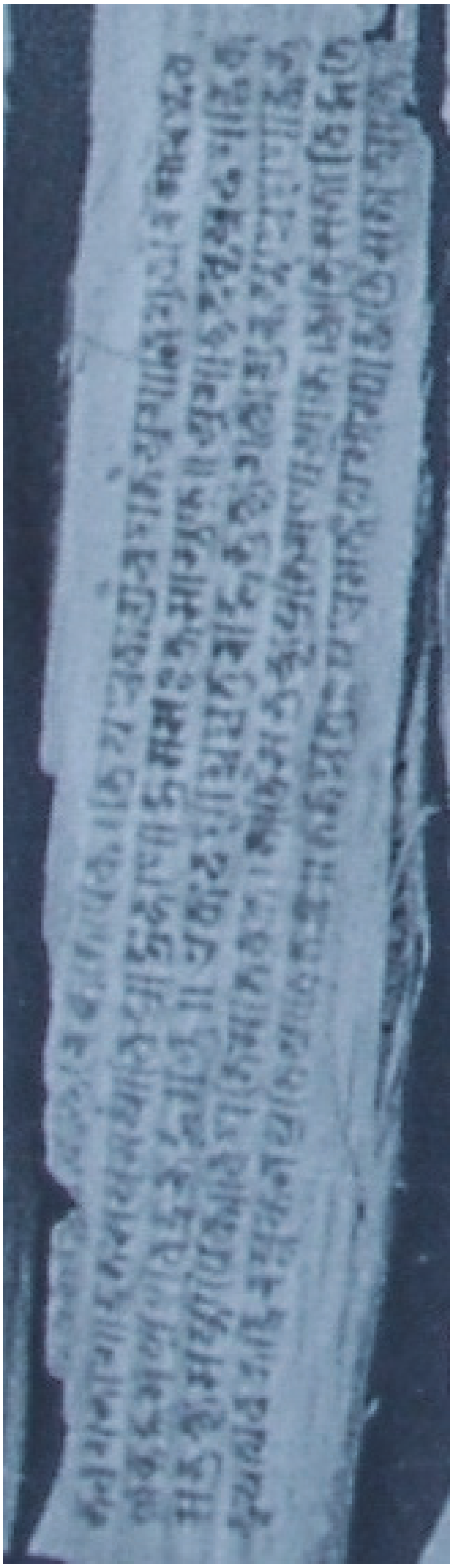


N_c101v(c)

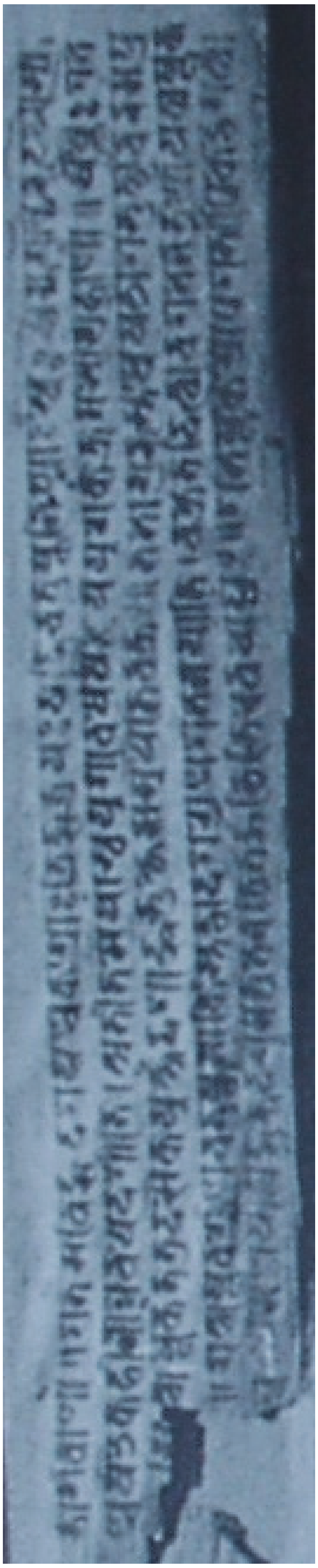
incipit: [śataṃ saṭpaṃcaka] ++++ + <hadvi> + <ko>ttarikā tathaikā | (79.35ab; Pingree 1978 I: 500)



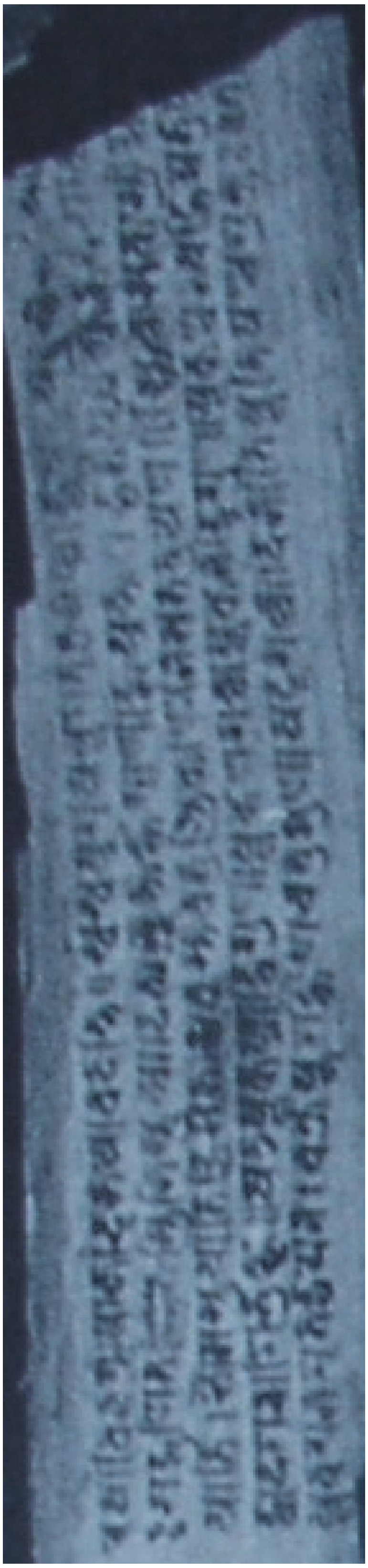
N_t102r (N_t2.1r = exposure yj02)



N_t102r(a)

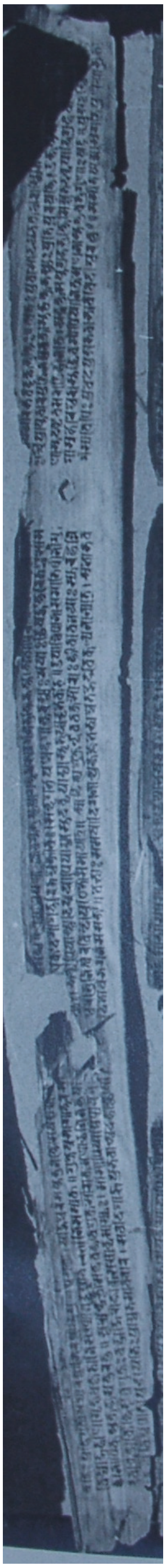


N_t102r(b)

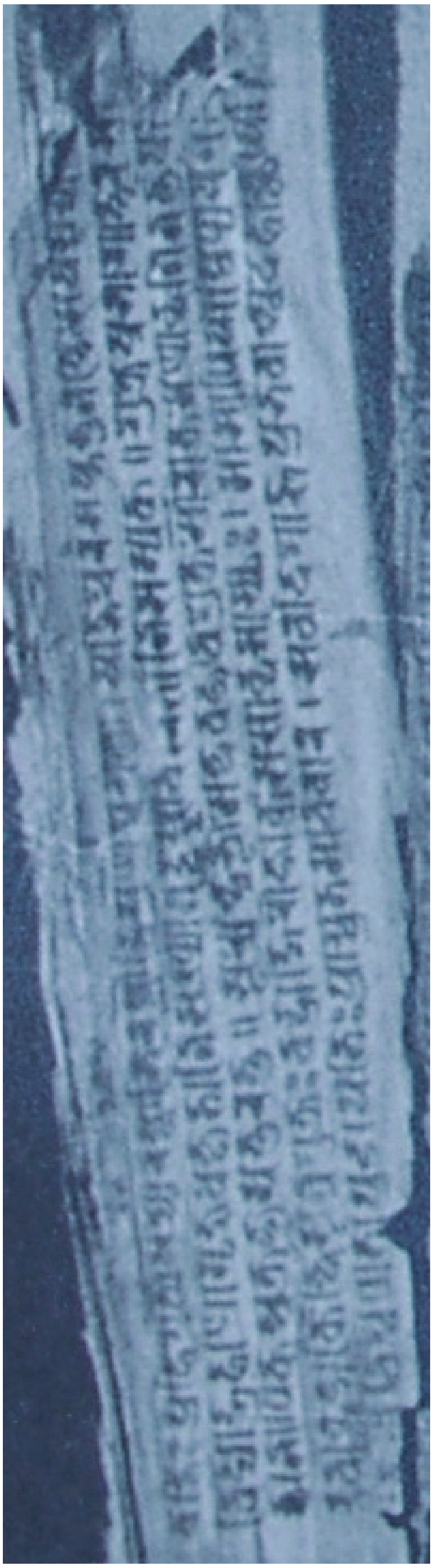


N_t102r(c)

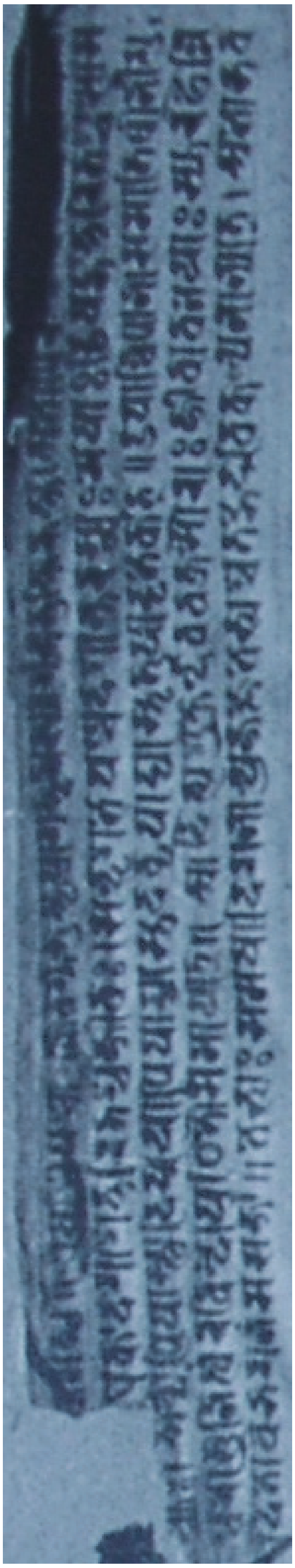
incipit: [tā? +]caḍbhiḥ prahigatyaṣaṭsyu[r...] (79.47a; Pingree 1978 I: 503)



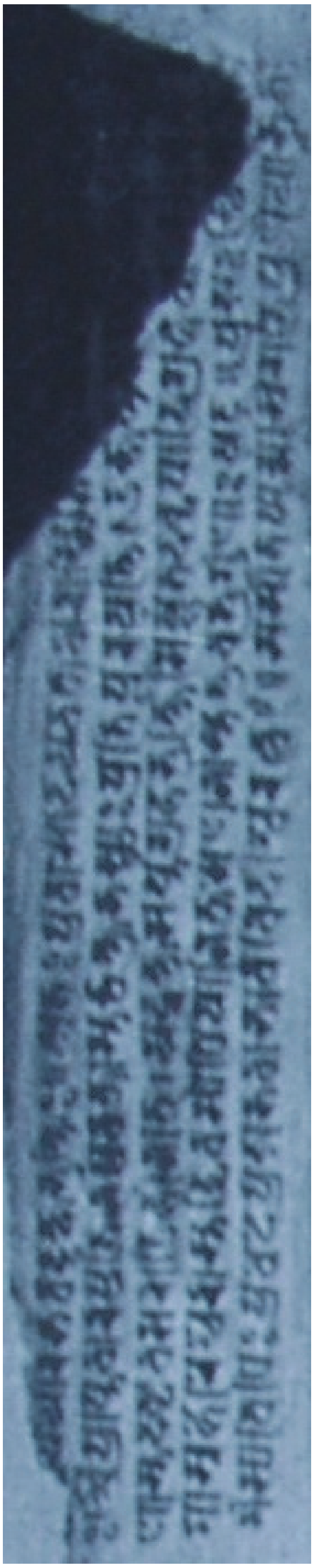
N_t102v (N_t2.1v = exposure yj01)



N_t102v(a)

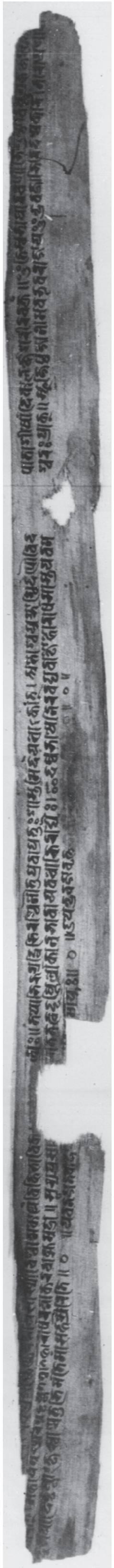


N_t102v(b)

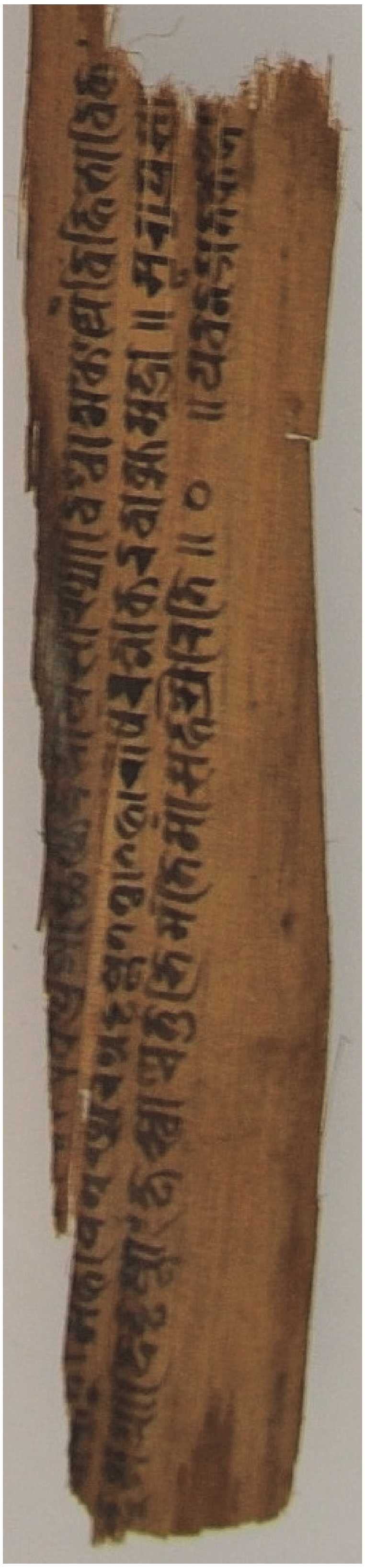


N_t102v(c)

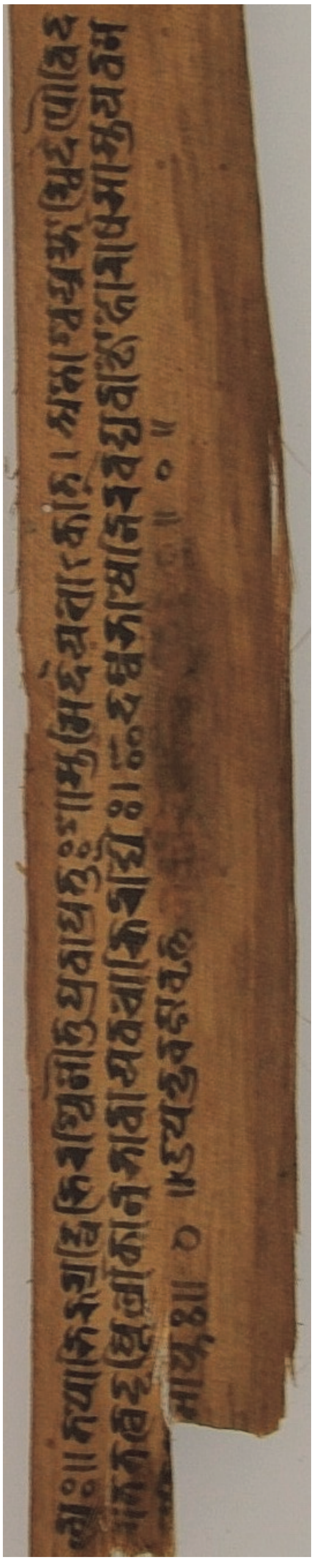
incipit: [bhūtā]... <va>prajāsthityudayāyasākhyo (79.58bc; Pingree 1978 I: 505)



N_{bw}103r (exposure 106b)



N_c103r(a)



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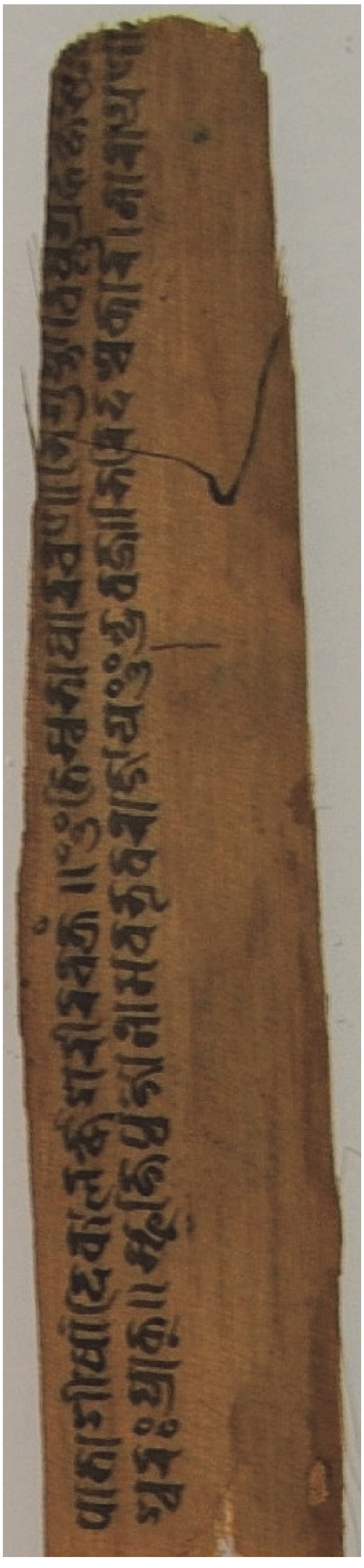
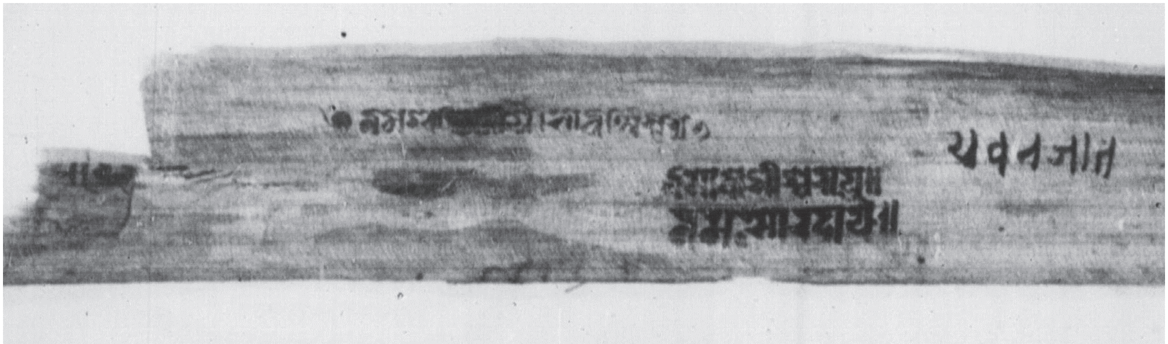


N_c103r(c)

N_{bw}103v(a)



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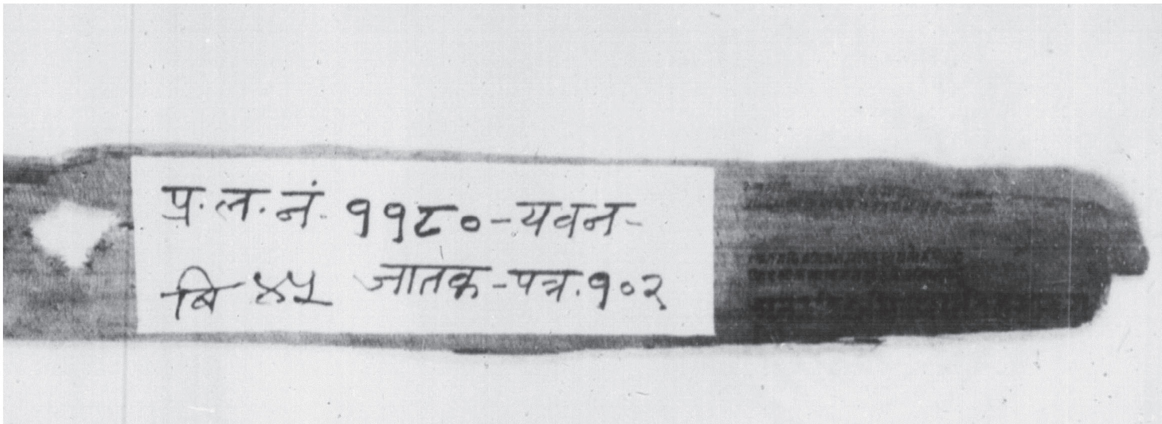
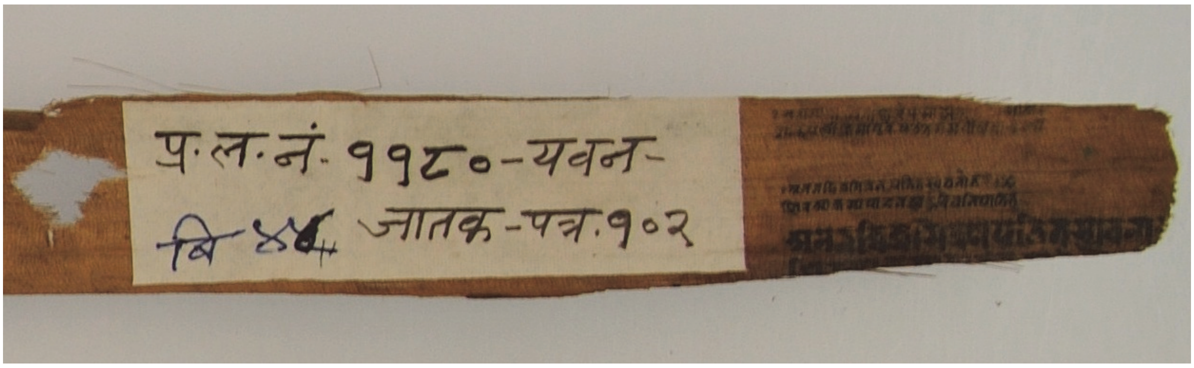


N_{bw}103v(c)

N_c103v(a)

N_c103v(b)



N_c103v(c)

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