

# The Date and Nature of Sphujidhvaja's Yavanajātaka Reconsidered in the Light of Some Newly Discovered Materials

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Résumé de l'article

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# History of Science in South Asia

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

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# The Date and Nature of Sphujidhvaja's *Yavanajātaka* Reconsidered in the Light of Some Newly Discovered Materials

Bill M. Mak

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## ABSTRACT

This paper examines a number of crucial verses from the last chapter of Sphujidhvaja's *Yavanajātaka*, a text that was widely believed to be the earliest Greek astral text translated into Sanskrit. In the light of some new materials, including a hitherto unreported Nepalese paper manuscript from the collection of the Nepal-German Manuscript Preservation Project (NGMPP), the date and nature of this important text are reconsidered.

## 1. INTRODUCTION

Since David Pingree's edition and translation of the Sphujidhvaja's *Yavanajātaka* in 1978, the text has established itself as one of the most important historical documents in various fields of Indology, from the history of mathematics and astral science, to Indian chronology and historical contacts among ancient cultures.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 discoveries concerning the text have been widely quoted by scholars in the past decades. These discoveries 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

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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 corrupted and clumsily expressed, contains algorithms of "ultimately Babylonian origin" and the earliest reference to the decimal place-value with a symbol for zero (*bindu*).

Pingree's discoveries were based largely on readings from the last section of the *Yavanajātaka*, described by him as "Chapter 79 - Horāvidhiḥ", an exposition of mathematical astronomy. In recent years, scholars including Shukla (1989) and Falk (2001) have pointed out some major flaws in some of Pingree's interpretations and reconstitution of the text. However, further progress of a proper reevaluation of the controversial contents of this chapter has so far been hampered by the lack of a better manuscript. In 2011–2012, additional materials including a hitherto unreported copy of the *Yavanajātaka* became available to the present author. This paper will therefore be the first attempt to reexamine Pingree's key interpretations of the *Yavanajātaka*, focusing on this last chapter, in the light of the new textual evidences.<sup>1</sup>

#### TEXTUAL SOURCES

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.

The "incorrectly written manuscript" N (folios 2–103) used by Pingree was in fact a microfilm of a Nepalese manuscript now in the possession of the National Archives in Nepal.<sup>2</sup> The beginning folio as well as f. 102 are missing from the microfilm. Although I cannot verify the microfilm used by Pingree himself

<sup>1</sup> A full critical edition of this last chapter is current under preparation and is due to be completed in 2013.

<sup>2</sup> 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.

(kept in the archives of Brown University), it should be very similar or possibly identical to the black-and-white Nepal-German Manuscript Preservation Project (NGMPP) A31/16 film made on 13.9.1970. The manuscript in these films was first described, together with a transcription of the last four verses by H. P. Shastri in 1897, following R. Mitra's initial survey of palm-leaf manuscripts in the Mahārāja's Durbar library.<sup>3</sup> Subsequently, Shastri himself and P. V. Kane (1955) continued to decipher the text.<sup>4</sup> A copy of Kane's transcript of the manuscript (ff. 2–10, 98–103) was made available to Pingree in 1958, which eventually became Pingree's K ("Kane"). Together with another the manuscript P ("Paris") from Sylvain Lévi's collection, the two manuscripts were used by Pingree to supply readings from the missing f. 102. Other manuscript fragments of the *Yavana-jātaka* were found by Pingree but their usefulness was limited. In addition, there were some important testimonia, most notably in the works of Mīnarāja and Ut-pala, whose readings often diverged from the manuscript readings.

The additional textual materials used in this paper come in three varieties:

- i) alternate copies of N;
- ii) an unreported copy of the *Yavana-jātaka*;
- iii) additional testimonia not reported by Pingree.

First of all, the microfilm Pingree used was not of the best quality, and that deficiency was exacerbated by the fact that the manuscript was already in a dilapidated state. In 1954, Giuseppe Tucci in fact took a complete set of photos of N (without f. 1 which was already missing, but with f. 102). Although the photo quality is less than desirable and is overall inferior to the black-and-white NGMPP film, it contains the missing f. 102 as well as critical readings at various places which were worn off or corrupted later on.<sup>5</sup> In addition, a set of high-quality color digital photos of N were made in 2011 which provides the best reading among all sources so far, despite the source being in a very poor condition.<sup>6</sup> These two new sources become our basis for improving on Pingree's reading of N.<sup>7</sup>

3 Shastri 1897: 310–311.

4 Shastri 1905: xxix–xxx, 40–41; 1911: 5–6.

5 I thank Francesco Sferra of Università degli Studi di Napoli "L'Orientale" who provided me with copies of Tucci's photos as well as relevant documents concerning the circumstances when they were taken (Sferra 2008; 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.

6 I thank also Harunaga Isaacson and Kengo Harimoto of Hamburg University for providing me the black-and-white copy of A31/16 as well as other MS fragments titled *Yavana-jātaka* in the NGMPP collections. The preparation of the color version of A31/16 as well as A1122–3 (see below) was facilitated by Isaacson and Albrecht Hanisch and was made available to me by Michio Yano.

7  $\mathfrak{N}\mathfrak{P}$  indicates Pingree's reading of N which is not supported by our manuscript sources.

In 2011, 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.<sup>8</sup> A digital set of color photos was produced (Q). Upon examination, this manuscript is found to contain significant readings which fill up some lacunae of our copies of N, as well as with significant variants. The manuscript contains 78 pages and was numbered up to 90, with therefore 12 pages missing. While this manuscript could be as late as the eighteenth century judging from the paper quality,<sup>9</sup> 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. As far as the “last chapter” is concerned, Q grouped chapters 77–79 of Pingree’s edition into one chapter with 104 verses in total, which is more than 101 verses in N.<sup>10</sup> Secondly, given the fact that Q contains variants significantly different from N and that the manuscript was copied at such a late date, there is a high chance of some other copies similar to Q being still extant in India and Nepal.

## 2. CRITICAL REMARKS

Pingree’s edition of the *Yavanajātaka* contains 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.<sup>11</sup> The purported last chapter is unique in the sense that it deals with mathematical astronomy, the application of which was presumed in dealing with horoscope data such as date and planetary positions, but was usually treated separately in treatises belonging to the *gaṇita* (calculation) category.<sup>12</sup> The contents of this pur-

8 At the top of the first folio of the manuscript was written in modern pen writing “*śa* 2387 / *vidhā* / *vṛhadyavanajātakam*”. While I cannot verify the particulars concerning this note, it may be noted that Shastri in his report also once described N as “*vṛhadyavanajātaka*” in which he later corrected to “*vṛhatsaṃhitā*” (Shastri 1905: xxix–xxx).

9 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 seventeenth century based on the orthography and the red lines used for alignment.

10 The additional 3 verses are located in the missing pages and unfortunately cannot be identified.

11 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.

12 The three categories of *jyotiḥśāstra* according to Varāhamihira’s sixth-century CE *Bṛhatsaṃhitā* (1.9, ed. Tripāthī) that later became largely standard are: i) *gaṇita* or *tantra* (mathematical astronomy); ii) *horā* or *jātaka* (genethliacal astrology or horoscopy); iii) *saṃhitā* (collection of natural astrology and divinatory practices). It may be noted that while the *Vedāṅgajyotiṣa* attributed to

ported last chapter are remarkable in the sense that they are amongst the oldest Sanskrit *jyotiṣa* texts dealing with planetary motion and the computation of the number of civil days (*ahargana*), if not the oldest extant; some of their features are attested in neither the surviving Greek sources nor the Indian ones. Nonetheless, the uniqueness of the work coupled with Pingree's assumption of the corrupted nature of the manuscript led to his rather free emendations of the text, resulting in some highly questionable and some certainly wrong interpretations of the contents of the *Yavanajātaka* as we shall see in the examples below.

#### NUMERIC AND ALGORITHMIC EXPRESSIONS

In 1989, K. S. Shukla wrote a review on the last chapter of Pingree's edition of the *Yavanajātaka*, which he described as "marred by faulty editing, the incorrect readings being adopted and the correct ones given in the apparatus criticus, with the result that the translation is incorrect at places and the meaning really intended by the author is lost." In total, Shukla retranslated 10 verses,<sup>13</sup> all dealing with time-measures and calculation of various time units in a *yuga*. What Shukla had essentially pointed out is that Pingree had failed to grasp the internal logic of the text and the numeric expressions by which numbers were expressed either normally [i–ii] or compositionally [iii–vi]:

<i>ekaṣaṣṭiḥ</i> (61 intercalary months in a <i>yuga</i> [abbr. i.y.] – v. 10)	[i]
<i>ṣaṣṭiḥ śataṃ pañcayutaṃ</i> (60 + 100 + 5 = 165 years i.y. – v. 3)	[ii]
<i>sahasraṃ apasaptaṣaṭkam</i> (1000 – 7 × 6 = 958 omitted days i.y. – v. 5)	[iii]
<i>pañcāṣṭakāikena yutena yuktaṃ dviguṇaṃ sahasraṃ</i> (5 × 8 + 1 + 2 × 1000 = 2041 synodic months i.y. – v. 20)	[iv]
<i>ṣaṭpañcakāgrā dviṣaṭi sahasraṃ ayutāni ṣaṭ</i> (6 × 5 + 200 + 1000 + 60000 = 61230 <i>tīthi</i> -s i.y. – v. 6)	[v]
<i>śate dve trikṛdaṣṭakāgre ṣaṭ cāyutāni</i> (100 × 2 + 3 <sup>2</sup> × 8 + 60000 = 60272 civil days i.y. – v. 7)	[vi]

While the expressions appear to be quite straight-forward, Pingree chose to read or emend them rather arbitrarily:

Lagadha contains also elements of astrological nature such as the description of the governing deity for each *nakṣatras*, it deals 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.

<sup>13</sup> Shukla (1989) translated vv. 5–7, 11–13, 19, and 28–29.



*New Edition.*

*kramaṇa candra<sup>A</sup>-kṣaya-vṛddhi-lakṣyas tithiś caturmāṇa-vidhāna-jīvam<sup>B</sup> |  
 ṣaṭpañcakāgrā dviśatī<sup>C</sup> sahasraṃ teṣāṃ<sup>D</sup> yuge<sup>E</sup> viddhy ayutāni<sup>F</sup> ṣaṭ ca ||6||*

<sup>A</sup>candra] N<sub>sed</sub>, candrah N<sub>ṭ</sub>  
<sup>B</sup>jīvam] N, bījah p<sub>ed</sub><sup>sed</sup>,  
<sup>C</sup>kāgrādviśatī] Ns, kāgre dviśate p<sub>ed</sub>  
<sup>D</sup>teṣāṃ] p<sub>ed</sub><sup>sed</sup>, teṣā N  
<sup>E</sup>yuge] p<sub>ed</sub><sup>sed</sup>, yudhi N, pradhi N<sub>ṭ</sub>  
<sup>F</sup>viddhyā°] s<sub>ed</sub>, vidyā° N, bindu° p<sub>ed</sub>

*Pingree's Translation.*

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*.

*New Translation.*

The *tithi*, which is to be defined as the gradual waning or waxing of the Moon, is the soul of the principles of the four (systems of time-) measurement. Know that there are 60000 plus 1000 plus 200 and 6 times 5 (i.e. 61,230) of them (i.e., *tithi*-s) in a *yuga*. "

The number of *tithis*, 61230[v], is given here in a typical composite expression. Pingree chose to interpret *teṣāṃ* as referring to days (*dināni*) instead which led him to read **60265** = 65(!) + 200 + 60000 = 60265 "days". Pingree's reading is impossible not only because the juxtaposition of number necessarily entails multiplication which Pingree himself well understood,<sup>14</sup> but also for the obvious error of leaving out the thousand (*sahasram*). The wrong interpretation led Pingree to the remark that "a more logical order might be achieved by interchanging 6c-d with 7c-d" and that "Sphujidhvaja gives only approximation".<sup>15</sup> The number given by Pingree is indeed closer to the actual number, **60272** days in a *yuga* which was given in v. 7:

*New Edition.*

*triṃśanmuhūrtam dinarātram uktaṃ sūryodayāt kālābudhās tad āhuḥ |  
 teṣāṃ śate<sup>A</sup> dve trikṛdaṣṭakāgre<sup>B</sup> ṣaṭ cāyutāny<sup>C</sup> arkayugaṃ vadanti |7|*

<sup>A</sup>śate] p<sub>ed</sub><sup>sed</sup>, sate N  
<sup>B</sup>trikṛdaṣṭakāgre] Ns, triśad ekakāgre p<sub>ed</sub>  
<sup>C</sup>ṣaṭcā°] N, ṣaṭkhā° p<sub>ed</sub>, ṣaṭkā° s<sub>ed</sub>

14 Pingree read *ṣaṭpañcakena* as 30 in v. 19.

15 Pingree 1978 II: 406.

*Pingree's Translation.*

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*).

*New translation.*

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 60000 plus 200 plus  $3^2$  times 8 (i.e., 60,272) of them (civil days).

The number of days in a *yuga* is here given as 60272 [vi]. The expression for square (*-kr̥t*) is well attested and is understood also by Pingree later in v. 23,<sup>16</sup> but he chose to emend the phrase *śate dve trikṛḍaṣṭakāgre ṣaṭ cāyutāni* to *śate dve trīsadekakāgre ṣaṭ khāyutāni* to force the number to read  $200 + 30(!) + 61000(!) = 61230$ , which is the number of *tithis*, not the number of days. Errors such as these are found throughout Pingree's translation, but even more alarming was his emendation or rather, insertion of expressions such as *bindu* and *kha* to represent zero in the two examples above (hence, *vidyayutāni ṣaṭ > binduyutāni ṣaṭ; ṣaṭ cāyutāni > khāyutāni*). Thus, Pingree claimed,

[i]f 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.<sup>17</sup>

In fact, both *bindu* and *kha* are not only fictitious but also superfluous. In other words, there is nothing clumsy about Sphujidhvaja's expressions and the *Yavanajātaka* provides no evidence of the use of the place-value system or zero, let alone instances of their earliest use.<sup>18</sup> Similarly, Pingree's implicit suggestion of

<sup>16</sup> Thus he read *trayas trayas tṛkr̥t (str̥v̥rn N) ṣadgunītās...liptās* in v. 23a as "57 minutes" ( $3 + 3^2 \times 6$ ).

<sup>17</sup> *Ibid.*, 406, also 407.

<sup>18</sup> This is not so surprising, given the fact that although the idea of void or null is certainly present in earlier Indian philosophical works and treatises on prosody (*chandas*) and grammar (*vyākaraṇa*), as many scholars have been keen to point out, nevertheless the inscriptional evidence for the use of zero as a decimal-

place figure in India proper is surprisingly late. One of its first instances is generally recognized to be the Gwalior inscription of 876 CE where zero was in a list of donated items (Datta & Singh 1935: 42,54). The earliest specimen of place-value notation in India is dated somewhat earlier in 693 CE, but as Salomon pointed out, undisputed cases of such notation are scarce through the eighth century CE (Salomon 1998: 62). See also fn. 38.

the use of *bhūtasamkhyā*, the idiosyncratic way of representing numbers by symbolic words such as *śara* to mean five was based completely on his own emendation which is highly doubtful.<sup>19</sup> In v. 9, we find the expression *śatadvayaṃ śaṭ dviguṇaṃ sahasraṃ* (2206) which Pingree emended to *śatrīśat śaḍ dviguṇaṃ sahasraṃ* (2041 = 5 + 30 + 6 + 2000).<sup>20</sup> The emendation is extremely doubtful, not only because single digit numbers are never combined in this way as we have seen already, but also because the use of *bhūtasamkhyā* is not found elsewhere in the text, which employed standard numeric expressions despite the metrical constraint - a point that has serious consequence in Pingree's interpretation of the "dates" of the text as we will see.

The correctness of our readings of the numbers in the text may be shown by the fact that they do agree with each other with minimal or no emendation to these composite numeric expression and algorithms. Hence, the number of *tithis* equals the number of synodic months times thirty: **61230** [v] = **2041** [iv] × **30**; the number of intercalary months equals the difference between the number of synodic months and and the number of solar months: **61**[i] = **2041** [iv] – **165** [ii] × 12, as given in the following verse which Pingree failed to interpret correctly:

*New Edition.*

*dinaṃ catuḥṣaṣṭi<sup>A</sup> -lavônam āhus tithiṃ<sup>B</sup> †yuśabdāntyam<sup>C</sup> † ahas tu sarvam |  
triṣaṣṭibhāgena yutaṃ<sup>D</sup> sahasraṃ yuge 'vamānām<sup>E</sup> apasaptaṣaṭkam<sup>F</sup> | 5 |*

<sup>A</sup>catuḥṣaṣṭi] *p<sub>ed</sub>*, catuṣaṣṭi N

<sup>B</sup>tithiṃ] *p<sub>ed</sub>*, tithi N

<sup>C</sup>yuśabdāntyam] N, praśabdāntyam N<sub>p</sub>, praṣaṣṭyantyam *p<sub>ed</sub>s<sub>ed</sub>*

<sup>D</sup>triṣaṣṭibhāgena yutaṃ *s<sub>ed</sub>*, triṣaṣṭibhāgaṃ navataḥ N, dviṣaṣṭibhāgaṃ navatiḥ *p<sub>ed</sub>*

<sup>E</sup>vamānām] s, tumānām N, tv ṛtūnām *p<sub>ed</sub>*

<sup>F</sup>apasaptaṣaṭkam] N*s<sub>ed</sub>*, apaśuddhaṣaṭam *p<sub>ed</sub>*

<sup>19</sup> It should be noted while Pingree assumed the use of *bhūtasamkhyā*, decimal place-value and zero in the *Yavanajātaka*, these concepts do not necessarily presuppose each other. *Bhūtasamkhyā* as word symbols without place-value is used in Pingalā's *Chandaḥsūtra*, dated generally before the second century BCE (Datta and Singh 1935: 58; Sarma 2009: 68–70). The earliest attested usage of *bhūtasamkhyā* with place-value is found somewhat later in the works of Varāhamihira (505–587 CE) such as the *Pañcasiddhāntikā*. The spuriously emended verses from Pingree's edition of the last chapter of the *Yavanajātaka* have often been

quoted as the earliest instance of the full use of *bhūtasamkhyā*, with place-value and zero, prior to Varāhamihira (Hayashi 1993: 24; Sarma 2009: 70–1; for other "controversial" instances, see Diller 1995: 59, 65 fn.25).

<sup>20</sup> 2206 is the number of sidereal months in a *yuga* or the number of lunar revolutions, whereas 2041 is the number of synodic months in a *yuga*. Pingree's emendation is motivated apparently by his desire to make the numbers agree in his scheme. Here, Shukla implicitly agreed with Pingree because he had no access to the manuscript and had to rely solely on Pingree's reading (Shukla 1989: 214).

*Pingree's Translation.*

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 (*rtu*), (each) consisting of 62 (*tithis*).

*New Translation.*

They say that a *tithi* is equal to a day minus 1/64 (of a day) while a whole day is equal to (a *tithi*) plus 1/63 (of a *tithi*)... The number of omitted *tithis* (*avamānām*) in a *yuga* is equal to 1000 minus "7 times 6" (i.e.,  $1000 - 42 = 958$ ).

Another interesting feature of the text is the use of time-measures which are defined in vv. 28–29. Their relations are given as:  $3 \frac{1}{8}$  *palas* = 1 *kuḍava*; 61 *kuḍavas* = 60 *liptās* = 10 *kalās* = 1 *nāḍikā*; 60 *nāḍikās* = 1 nychthemeron; 790 *nimeṣas* = 1 *kalā*; 2 *nāḍikās* = 1 *muhūrta*; in terms of values in increasing order: *nimeṣa*  $\simeq 0.18''$ , *pala* 7.55'', *kuḍava*  $\simeq 23.61''$ , *liptā* 24'', *kalā* 2' 24'', *nāḍikā* 24', *muhūrta* (or *kṣaṇa*) 48', *dyuniśā* (or *ahorātra*) 1 day or 24 hours. With the exception of *muhūrta* and *liptā*, which are defined the same across practically all extant Sanskrit texts, all others vary. It is noteworthy, however, that the relation of 1 *nāḍikā* = 10 *kalās* implied here is used also in *Suśruta* and *Parāśara*, and may be related to the *Vedāṅgajyotiṣa* as Shukla suggested.<sup>21</sup> Pingree read in N *kalāstāraśanāḍikās* as *kalās trīṃśa* <ca> *nāḍikās*, resulting in the erroneous relation of 1 *nāḍikā* = 30 *kalās*. The correct reading should be *kalās tā daśa nāḍikās* which lead to the agreement of figures given in vv. 11–13 where the unit was used.<sup>22</sup>

## ASTRONOMICAL CYCLE AND BEGINNING OF THE YUGA

One of the key features of the *Yavanaajāṭaka* is the use of an astronomical cycle of 165 years. Sphujidhvaja was aware of other types of astronomical cycles used by others (*kecit*), namely the Great Solar Yuga (*mahat sauram*) and the Smaller Yuga (*sūkṣmam*) for predicting the eclipses (*grahaṇārtham*) as described in v. 2. While the *yuga* has been defined differently throughout the ages in India, the 165 years cycle is, however, not attested in any Greek or Sanskrit sources.<sup>23</sup>

21 The relation given is possibly a rounded off figure from the definition of 1 *nāḍikā* = 201/20 *kalās* in *Vedāṅgajyotiṣa* (Shukla 1989: 213).

22 *Ibid.*, 217–220.

23 That is, equivalent to the cycle of 2041 (165 × 30) synodic months (Pingree 1978 II: 406). Pingree suggested that *yugaṃ mahat sauram* refers most likely to the *Mahāyuga* of

4,320,000 years and commented that such a *Mahāyuga* is "certainly known in India by the second century A.D." (Pingree 1963: 238). We are, however, not certain what *Mahāyuga* refers to or about the date of this concept. The *Manusmṛti* describes a *Divyayuga* of 12000 years while the *Viṣṇupurāṇa* describes a *Mahāyuga* of 4,320,000 years. For the five-year *yuga* of the Vedic period, see Achar 1997.

At the start of a series of verses that concern the calculation of time, the date of the epoch was given in relation to the Śaka era as follows:

*New Edition.*

gate ṣaḍagre<sup>A</sup> 'rdhaśate samānām kālakriyāntatvam<sup>B</sup> idaṃ śakānām |  
ravir yuge<sup>C</sup> sūryadine prapede<sup>D</sup> kramāt tadabdādi yugādi bhānoḥ | 14 |

<sup>A</sup>ṣaḍagre] N, ṣaḍ eke *p<sub>ed</sub>*

<sup>B</sup>kālakriyāntatva°] N, kālakriyātattva NṢ

<sup>C</sup>raviryuge] emend., raveyuśam N, raveruṣe *p<sub>ed</sub>*

<sup>D</sup>prapede] emend., praderkaḥ N, †prade 'rket *p<sub>ed</sub>*

*Pingree's Translation.*

When 66 years of the Sakas 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.

*New Translation.*<sup>24</sup>

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.

Based on his interpretation of v. 14, Pingree put the epoch to 23 March 144 CE, calculated from the well-established Śaka era of 78 CE. Falk, on the other hand, pointed out that the epoch should be placed before and not after the Śaka era, as the elapsed years (*samānām*) are not to be construed with the Śakas (*śakānām*) in two phrases. Furthermore, Pingree's emendation of the numeric expression of ṣaḍagre 'rdhaśate (56) to ṣaḍ eke 'rdhaśate (66) is unwarranted and was motivated by his attempt to match the astronomical configuration of the conjunction of Sun and Moon at Aries 0° described in *pāda* cd.<sup>25</sup> Quite remarkably, Falk showed that the year 22 CE (78–56) he proposed fulfilled the astronomical requirement as well. However, as typical of any epoch, this is very likely to be a backward calculation created for historical or calculatory purposes and does not necessarily constitute proof of the system's antiquity as Falk claimed.<sup>26</sup> Nevertheless, if

24 I follow here Falk's reading: "When 56 years (of the *yuga*) have gone, this is the state of (the sky leading to) the epoch of the Śakas..." (Falk 2001: 124).

25 Pingree 1978 II: 408.

26 Thus Falk claimed the date to be "when people from the West (*yavana*) spread their astronomical knowledge in South Asia", coincid-

ing "with the early years of Gondophares' rule in India" (Falk 2001: 133). Backward calculation of epochs are well known, including the later *Siddhāntic* epoch of 3012 BCE, the Hijri year of 622 CE, or even the Anno Domini of our common era which was devised in 525 CE and popularized in the eighth century.

Falk's interpretation is correct, 22 CE should be at best taken as the *terminus post quem* of this chapter of the *Yavanajātaka*.

#### DATING AND AUTHORSHIP

The often quoted dates and authorship of the *Yavanajātaka* claimed by Pingree are based on the last three verses of the text:

*New Edition.*

*iti svabhāṣāracaṇā<sup>A</sup> tiguptād<sup>B</sup> viṣṇugraha<rkṣā>ṁṣu<mato>'vatārāt<sup>C</sup> | maharṣimukhyair<sup>D</sup> anudr̥ṣṭatattoṽd dhorārtha<sup>E</sup> ratnākaravāksamudrāt<sup>F</sup> | 60 |<sup>G</sup>*

<sup>A</sup>°racanā°] Q<sub>ped</sub>, °racanā° N, °varanā° Ns

<sup>B</sup>°tiguptād] emend. VASUDEVA, °bhigu<ptā> N, °bhiguptā Q, °bhiguptām Ns<sub>ped</sub>

<sup>C</sup>viṣṇugraha <rkṣā>ṁṣu<mato>'vatārāt] emend., viṣṇugraha<kṣā>ṁṣu++++<rā>t N, viṣṇugraha+...Ns, viṣṇugraha<kṣe>+tāvatārāt Q, viṣṇugraha+kṣe...<sub>ped</sub>, viṣṇugraheṣendumayāvātārāt] emend. YOKOCHI,

<sup>D</sup>ma<harṣi>mukhyair] emend. ISAACSON, ma+++mukhyair N, mahar<?i>mukhyair Q, ...Np, mahīpamukhyair <sub>ped</sub>

<sup>E</sup>°tattvād dho°] = °tattvāt ho° QN, °tattvām ho° <sub>ped</sub>

<sup>F</sup>°samudrāt] emend. ISAACSON Ns, °samudrā QN, °samudrām <sub>ped</sub>

<sup>G</sup>60] <sub>ped</sub>, 102 Q

*New Edition.*

*sūryaprasādāgatattvadṛṣṭir<sup>A</sup> lokānubhāvāya vacobhir ādyaiḥ | idaṁ babhāṣe niravadyavākyo<sup>B</sup> horārthasāstraṁ<sup>C</sup> yavaneśvaraḥ prak | 61 |<sup>D</sup>*

<sup>A</sup>sūryaprasādāgata°] <sub>ped</sub>, sūryaprasādāgata° Q, sūryaprasā+ga° N, sudhāprasā+nvita° Ns

<sup>B</sup>°vākyo] NQ, °vaktro Ns

<sup>C</sup>horārthasāstraṁ] <sub>ped</sub>, horārthasāstra N, horārthasāstra Q

<sup>D</sup>61] <sub>ped</sub>, 103 Q

*New Edition.*

*sphujidhvajo<sup>A</sup> nāma babhūva rājā ya indravajrābhir idaṁ cakāra | nārāyaṇārkendumayādidṛṣṭaṁ<sup>B</sup> kṛtsnaṁ<sup>C</sup> caturbhir matimāṁ<sup>D</sup> sahasraiḥ | 62 |<sup>E</sup>*

<sup>A</sup>sphujidhvajo] NQ, sphūrjjidhvajo Ns

<sup>B</sup>nārāyaṇārkendumayādidṛṣṭaṁ] emend.,

nārāyaṇārkendumayādidṛṣṭaṁ Q, nārāyaṇā<rke>ndumayādidṛṣṭo N, nārāyaṇāṅkendumayādidṛṣṭaṁ Np, nārāyaṇāṅkendumayādidṛṣṭvā Ns, nārāyaṇārkindumeśādidṛṣṭaṁ emend. FALK 2007: 143 fn2,

nārāyaṇāṅkendumitādbadṛṣṭaṁ <sub>ped</sub>

<sup>C</sup>kṛtsnaṁ] <sub>ped</sub>, kṛtsnāṅ Q, kṛtsvāṅ N, kṛtvā Ns

<sup>D</sup>matimāṁ] QN, matimān Ns<sub>ped</sub>

<sup>E</sup>62] <sub>ped</sub>, 104 Q

*Pingree's Translation.*

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 genethliology for the instruction of the world by means of excellent words. There was a wise king named Sphujidhvaja who versified this entire (text), which was seen by him in the year 191, in 4,000 indravajra verses.

*New Translation.*

In the past Yavaneśvara, whose vision of truth came from the grace of the Sun, whose sentences are blameless, from jewel-mine of horoscopy which is an ocean of words, [whose meaning] was very obscure by reason of being written in his own language (svabhāṣā-),<sup>27</sup> whose truth was revealed by the foremost of great sages, which was descended from Viṣṇu, the planets, the nakṣatra-s and the Moon, taught this treatise of horoscopy in excellent words for the benefit of the world. There was a wise king named Sphujidhvaja who composed this entire (text), which was beheld (-dṛṣṭam) by Viṣṇu, the Sun, the Moon, Maya and so on, in 4,000 indravajrā verses.

Pingree's reading of *viṣṇugraha* in v. 60 as 71, which became the basis of his dating of Yavaneśvara's original prose exemplar (78 + 71 = 149/150 ce), as well as the idea of "two names" and "two dates", are in fact not original, but were adapted from Shastri's report and transcription of the text dated 1897.<sup>28</sup> Shastri read *viṣṇugraha* as 91, which was later adopted by Kane.<sup>29</sup> Pingree disputed the reading with the argument that the inclusion of the pseudoplanets *Rāhu* and *Ketu*

27 Alexis Sanderson (personal communication) pointed out that the phrase *svabhāṣā-racanātiguptāt* seems to be "an oddly hyperbolic way of referring to the fact that the original was in a language other than Sanskrit". He thus proposed the possibility of the phrase meaning that "the meaning of the text was completely obscure by reason of being written in an [unfamiliar] jargon." Such usage of the term *bhāṣā*, taken as synonymous with *paribhāṣā* to refer to "jargon" and not "language," appears to be attested. This interpretation is indeed favorable if we take the non-*bhūtasamkhyā* interpretation of the new manuscript reading of v.60b. In

other words, it is rather unlikely that author considered a text promulgated by Viṣṇu to be originally composed in Greek.

28 "There are evidently two names and two dates. The first is Yavaneśvara, 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 Sphūrjiddhvaja in 191 of the same era who rendered the translation into 4,000 Indravajrā verses" (Shastri 1897: 311–312).

29 Kane 1955: 1. Furthermore, Kane speculated the era to be Gupta.

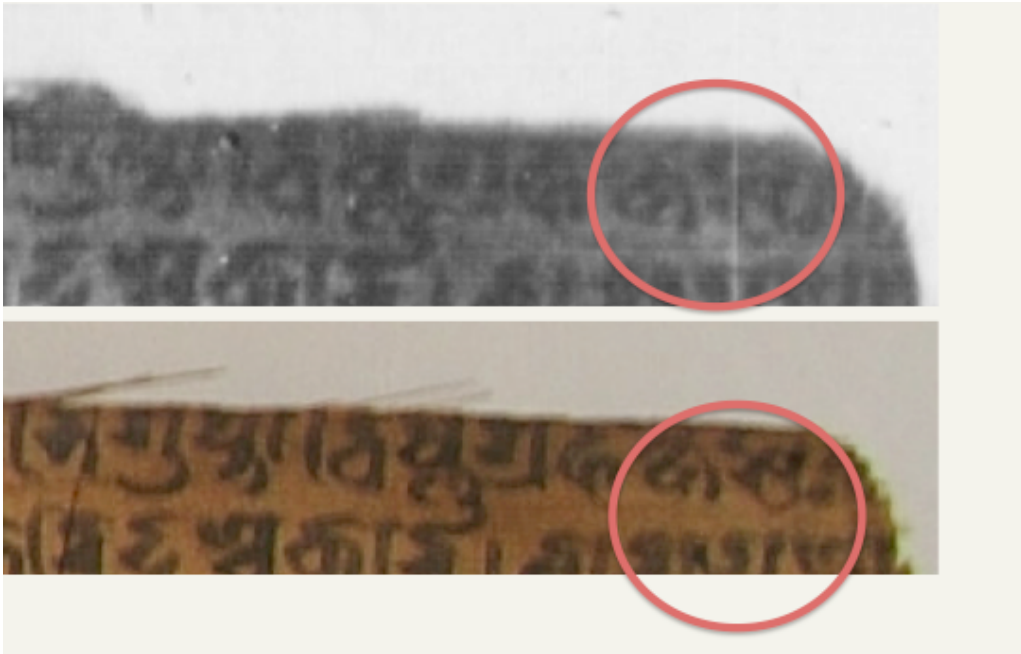


Figure 1: A fictitious *bhūtasamkhyā*? N 103r (enlarged). *viṣṇugrahakṣāṅśu...* (YJ 79.60b).

among the planets (*graha*) was “an impossibility in the second century”, but accepted nonetheless the assumption of the *bhūtasamkhyā*.<sup>30</sup> The problem with this reading is the broken *akṣara*-s which follow, unreported by Shastri but reported by Pingree to be a mysterious “*kṣe*” marked with an obelus, which could in fact be “*kṣāṅśu*” (Q) or “*rkṣāṅśu*” (as I emended).<sup>31</sup> Leaving aside the problem of the unattested usage of *viṣṇu* to represent one, this extra syllable makes the *bhūtasamkhyā* highly unlikely if not impossible.<sup>32</sup> As Falk had pointed out, such conversion “is not required or necessary” and “the truncated line may well refer to ‘the sun and the planets’”.<sup>33</sup> It should also be noted that while it is not certain whether *svabhāṣā*- in 60a refers to Greek, judging from the Indian contents found throughout the *Yavanajātaka*, from the description of 28 *nakṣatras* in an exposition of traditional Indian *yātrā* military astrology,<sup>34</sup> to all the Indian elements such as description of Indian deities, *Āyurveda* and even the *Kāpālikas* which are not attested in any Greek source at all, the prose version is extremely unlikely to be Greek, that is, if there was one.<sup>35</sup> As such, *Yavaneśvara* should be considered to be a reference to the attributed source and not to the author of a textual exemplar. It appears that the *Yavanajātaka* is an original amalgamation of Greek and Indian astral sciences.

<sup>30</sup> Pingree 1959: 282 fn.4.



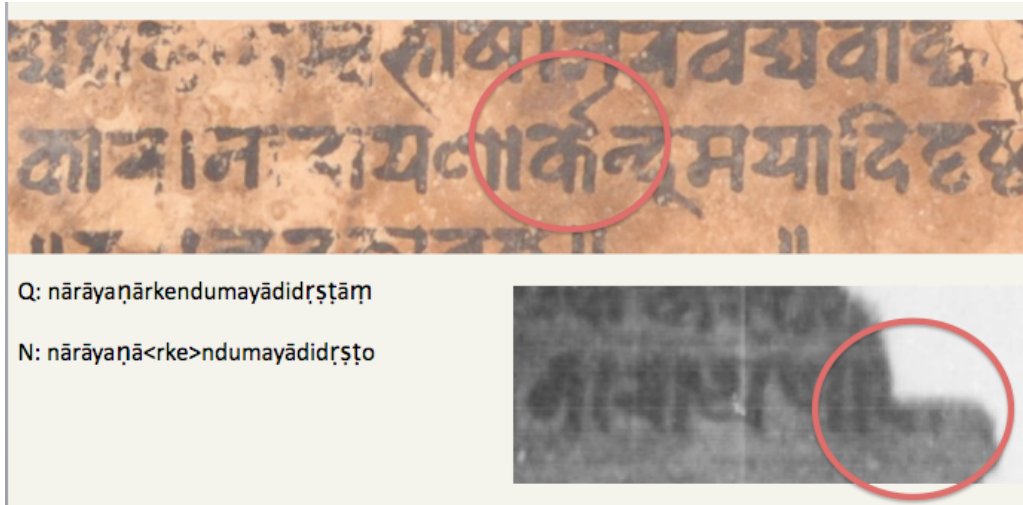


Figure 2: Another fictitious *bhūtasamkhyā*? Q90v (top), N<sub>bw</sub>103r (bottom). Note that although N is broken off, Pingree's emendation of *nārāyaṇāṅrike*...is unlikely since we would expect here a conjunct consonant *ṅrike/ṅika* as it is customary in this script (rather than an *anusvāra + ke/ka*),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

Pingree's famous reading of **191** (Śaka) years based on his emendation *nārāyaṇāṅkendumitābda* from *nārāyaṇārkendumayādi* similarly poses a series of major problems. First of all, his reading of the manuscript was faulty. All copies of N showed *-ārike* to be an impossible reading, which should read *-ārke* instead according to Q.<sup>36</sup> Secondly, it is highly doubtful that Sphujidhvaja employed *bhūtasamkhyā* at all as I have pointed out earlier; nowhere can it be shown that such system of numeric expression was used in this work. Thirdly, even if this turns out to be an exceptional *bhūtasamkhyā*, the reading *indu* (1) *arka* (12) *nārāyaṇa* (1) would generate an unlikely number of **1121**, 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!"<sup>37</sup> 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 Yavaneśvara and Sphujidhvaja respectively must be discarded.

31 I thank Harunaga Isaacson for pointing out to me the characteristic use of the ligature "ṅśu" to represent "ṁśu" in this manuscript. The important point here overlooked by Pingree is the last member of the compound -

*avatārāt* which very much removes the possibility of a *bhūtasamkhyā* on one hand, and points to a curious reference to the lineage of the text on the other. While my emendation appears

## 3. RECONSIDERATION OF THE YAVANAJĀTAKA

**D**rawing from our observations above, a somewhat different picture of the *Yavanajātaka* begins to emerge. In the first place, the text is not as corrupted 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*. Disappointing as it may sound, the early evidences for the use of zero in a place-holder system and the *bhūtasamkhyā* as Pingree identified in the *Yavanajātaka* must now be refuted. 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.<sup>38</sup>

to follow closer to the manuscript readings, Yūko Yokochi pointed out to me the striking resemblance between this *pāda* and v. 62c, and thus suggested the emendation *viṣṇugraheśendunayāvātārāt*. If this is indeed the case, the repetitiousness appears to me rather odd, unless one concedes that v. 62 after all was an accretion. Regardless which interpretation we take, this problematic *pāda* leads us to speculate about the possibility of four astronomical schools which must be known to Sphujidhvaja, although to my knowledge, Soma has never been ascribed to a text, while Viṣṇu, Sūrya and Maya are indeed well attested as the source of astral science of various schools. Readings from another manuscript would be immensely helpful.

32 If my emendation is correct, a forced *bhūtasamkhyā* reading may render the combination *viṣṇu + graha + ṛkṣa-* into the impossible figure of 2771 or 2871. The strangeness of *viṣṇu* to represent one has been noted by others (Sarma 2009: 66).

33 Falk 2007: 143 fn1. I have not adopted Falk's suggestion but took it more generally to refer to Sphujidhvaja's praising and justification of Yavaneśvara's excellence.

34 Chapter 73, vv. 18–20.

35 Pingree himself admitted that "...it is clear that much of Sphujidhvaja's material is de-

rived not from Greek sources, but from an ancient Sanskrit tradition of military astrology" but did not elaborate further why that was the case if the work was supposed to be a translation/versification of a Greek original. The subject was treated in greater details in a paper I presented earlier this year during the workshop *Vedica Neapolitana* in Procida, Italy (Oct 5, 2012). "The Hinduization of the Genethliacal Astrology – from *Yavanajātaka* to *Bṛhajjātaka*." A full version of the paper will appear in the journal of the University of Naples "L'Orientale."

36 Falk 2007's emendation of Pingree's °*āṅke*° to °*ārki*° was based on mere guessing, as informed to the author by Falk personally.

37 Falk 2007: 143 fn2.

38 See Staal 2009. It is curious that 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*. Regardless of whether Staal was aware of the unreliability of Pingree's assertion, one can say that nonetheless he was more interested in earlier evidences in what he called "beyond writing" and the "prehistory of zero" (Staal 2010: 6, 14 ff).

While many astrological concepts described in the first 78 chapters such as the ascendent (*horā* < ὥρα), decan (*drekkāṇas/drekāṇas/drekkas/drekas* < δεκαῶσ), minute (*liptā* < λεπτόν) must be connected to their Greek parallels given their blatant resemblance and the lack of antecedents in the Vedic corpus,<sup>39</sup> indigenous concepts such as *karma*, *Āyurveda* and references to Hindu deities, as well as elements not attested any extant Greek sources such as the *yuga* of 165 years must not be overlooked. Pingree's views that the latter reflects Sphujidhvaja's attempt of Hinduization and that the "Greek original from Alexandria" belonged to a lost school of Greek astronomy are at best conjectural. Specifically, 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.<sup>40</sup> Given 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.

As for the identities of Yavaneśvara and Sphujidhvaja, it should be noted that historically the two names must have been considered by at least some Indian paṇḍits to be referring to the same person.<sup>41</sup> Although this interpretation appears unlikely given the use of *prāk* in 61d and the unique description of the source in vv. 60–61 in contrast to v.62,<sup>42</sup> Yavaneśvara was likely a general attribution rather than a reference to a specific historical figure.<sup>43</sup> Pingree's treatment of the two names to refer to two unique individuals was motivated by his fictitious readings of the *bhūtasamkhyā*, which are now shown to be impossible.

The earliest "hard" evidences we have so far for the use of zero as well as *bhūtasamkhyā* are to be found somewhat surprisingly in the inscriptions of the Indianized kingdoms in Southeast Asia in late sixth and seventh, 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 nonetheless significance references, see Cœdès 1931: 323–328; Datta & Singh 1935: 60; Diller 1995: 68, 1996: 125–6; Salomon 1998: 61–63).

<sup>39</sup> For general discussion on Greek loans in Sanskrit, see Burrow 1955: 387–388; for specific discussion on astronomical loans, see Yano 1987.

<sup>40</sup> Incidentally, this last chapter was titled only "horā" and not "horāvidhi" as Pingree claimed. As pointed out earlier, Q grouped chapters 77–79 together as one chapter which was titled in the colophon as "horā". Rather remarkably in N, Pingree's chapters 77 and 78 were not given any title and Pingree conjectured them to be "karmārambhaḥ" and

"ārambhavidhiḥ" respectively in his edition. The title "horāvidhiḥ" is an emendation by Pingree and was not reported by Shastri when N was presumably in a better state (Shastri 1911: 5–6). Q reads simply *yavanajātaka horā parisamāptā*.

<sup>41</sup> Bhāskara quoted v. 55 twice in his commentary on the *Āryabhaṭīya*, attributed the verse to "Sphujidhvajayavaneśvara" (*uktam ca Sphujidhvajayavaneśvarena*), suggesting that Bhāskara understood Yavaneśvara and Sphujidhvaja to be the same person. Citations of the *Yavanajātaka* attributed to "Yavaneśvara" are found in Utpala's commentary on *Bṛhajjātaka* 7.9 (ed. Jhā) and *Bṛhatsamhitā* (as reported by Kern in his edition, quoted in Shastri - see next note). In fact, whenever the *Yavanajātaka* was quoted, Yavaneśvara was consistently referred to, not Sphujidhvaja.

<sup>42</sup> Shastri 1897: 312.

<sup>43</sup> The usage would be similar to the *yavanācārya* in later texts. It is doubtful that the title refers to a single person.

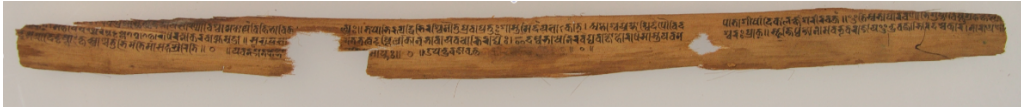


Figure 3: Last folio of N (103r). From top-left: ...<va>prajāsthityudayāyasākhyo... (YJ 79.58c).



Figure 4: Last folio of Q (90v). From top-left: *vidhiḥ pravēde prajābhavābhāvavid īśvaratoam* | (YJ 79.57c).

Furthermore, since it is not completely certain whether the colophon was written by Sphujidhvaja himself, its contents should not be accepted too hastily without reservation.<sup>44</sup> At any rate, there is no evidence of the existence of a Greek text in prose from which Sphujidhvaja versified, as Pingree claimed.

To sum up, the most we can say in the absence of further evidence is that the *Yavanajātaka* is an early Indian *jyotiṣa* text which incorporated elements of Greek astrology and astronomy. The unique *yuga* system it described suggests that it is a transitional work which modified upon prevalent *jyotiṣa* works such as the *Vedāṅgajyotiṣa*. It is dated some time after 22 CE and could be as late as the early seventh century when it was first quoted by other authors such as Bhāskara in his commentary on the *Āryabhaṭīya*. While the uncertainty of the dating of the

44 That is, v. 62 and possibly vv. 60–62. Although it is not usual for Sanskrit authors to refer to themselves in third person out of modesty (I thank Dominik Wujastyk for pointing that out to me), the phrase *sphujidhvajo nāma rājā* gives at least the possibility that this verse, and possibly the following ones as well, was composed by a disciple-scribe in the manner the *Vedāṅgajyotiṣa* was described as “the lore of time of the Great Sage Lagadha” (*kārajñānam lagadhasya mahātmanah*) proclaimed by the an-

onymous author in first person (*pravakṣyāmi*) in VJ-R 2 (see Kuppanna Sastry 1985: 35–36). The possibility that v. 62 could be a later addition may be further corroborated by the not so accurate description of the text, i.e., 4000 verses in *indravajrā* meter, when the actual number of verses was likely to be less (though possibly more than the 2270 verses reported in Pingree’s edition given the evidences from Q - see above) and the verses, technically speaking, in *upajāti* meter.

*Yavanajātaka* may be upsetting to some, it creates also new, interesting questions to be answered. For example, the *kāpālikas* or the “skull-bearers” (translated by Pingree rather inconsequentially as “beggars”) described in the text (v. 62.25) would have been taken in the past as a remarkably early reference to the tantric Śaiva cult; now, suchlike references have to be reexamined together with other materials outside the text which may in turn provide us hints for the true dating of the *Yavanajātaka*.<sup>45</sup> Even more challenging questions are posed by a number of parallel passages found in the *Sārāvalī* of Kalyāṇavarma and the *Vṛddhayavanajātaka* of Mīnarāja (a work twice the size of the *Yavanajātaka*), as well as a handful of hitherto unexamined manuscripts all bearing in their titles variations of “*Yavanajātaka*” purportedly authored by certain *Yavanācārya*(s).<sup>46</sup> For decades, Pingree assumed that these works simply quoted from or were influenced by the *Yavanajātaka* of Sphujidhvaja. Given that the dating of the text has now been put into question, their relationship must be reexamined, together with many yet unidentified or unread *jyotiṣa* manuscripts and fragments in collections such as the NGMPP.

### ABBREVIATIONS

N	NGMPP A <sub>31</sub> /16 = NAK 1180/vi.jyaut.45, 103 ff.
N <sub>t</sub>	Tucci 13(XLIX.21–38) and 34(ex35) (XLII.1–9), dated 1954, ff. 2–103.
N <sub>bw</sub>	NGMPP black-and-white microfilm, dated 1970, ff. 2–101,103.
N <sub>c</sub>	NGMPP color photos, dated 2011, ff. 2–101,103.
N <sub>p</sub>	Pingree’s reading of N (N <sub>p</sub> = reading unsupported by MS reading)
N <sub>s</sub>	Shastri (1897)’s reading/emendation of N
Q	NGMPP A <sub>1122</sub> /3
P	As reported by Pingree 1978: 23. Copy of N made for P. V. Kane, dated c. 1955, recopied by Pingree in 1958, ff. 2–10, 98–103.
K	As reported by Pingree 1978: 23. MS A.3 of the collection of Sylvain Lévi, copied c. 1890, 66 ff.
B	Bhāskara’s commentary on <i>Āryabhaṭīya</i> ( <i>kālakriyāpāda</i> . Shukla 1976 edition.
U	Uṭpala’s commentary on <i>Bṛhajjātaka</i>

<sup>45</sup> The term is found in Sanskrit literature from sixth century onward: *Kāpālika* was mentioned in the chapter on omens, “Circle of Quarters” (*antaracakram*), in Varāhamihira’s *Bṛhat-saṃhitā* (v. 86.22). Earlier reference in Prākṛit is found in Hāla’s *Gāthāsattasāi* (Skt. *Gāthāsattasāi*), dated generally third to fifth century CE

(Dyczkowski 1988: 26).

<sup>46</sup> See for example the description of various *Yavanajātaka* MSS (Kane 1955: 2). Pingree had made a brief survey of these works though it is by no means exhaustive and much of the contents are yet to be deciphered (Pingree 1978 I: 28–39).

<i>p<sub>ed</sub></i>	Pingree's emendation 1978
<i>s<sub>ed</sub></i>	Shukla's emendation 1989
<...>	reconstruction from unclear reading
†...†	obelus: problematic/uncertain reading

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