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Gaṇitagannaḍi: A *Karaṇa* Text of 1604 CE on *Siddhāntic* Astronomy in Kannaḍa

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INTRODUCTION

A WEALTH OF SIDDHĀNTIC ASTRONOMY TEXTS has been brought to light in recent decades. While the texts from Kerala constitute a very large share of texts in languages other than Sanskrit, texts in many other languages have also been unearthed (Sarma 2002; Srinivas 2019). Telugu texts such as *Gaṇakānanda* (Padmaja et al. 2019) and the *Tyāgarti* tables in Kannaḍa have been brought to light (Rupa et al. 2014). They were in use during the fifteenth to seventeenth centuries in South India. Many more texts are yet to be discovered. The present study concerns another text, hitherto unknown, with a unique technique for obtaining planetary positions starting with the number of days lapsed since epoch (Sanskrit *ahargaṇa*).[1] The original *karaṇa* text called *Vārṣikatantrasaṅgraha* was written by a scholar named *Viddaṇācārya* and has not been published.[2] However, fortunately, two commentaries on this, written by Śaṅkaranārāyaṇa Jōisaru in the first decade of seventeenth century are available. Here we discuss the unique technique he employed for calculations.

1 ABOUT THE AUTHORS

THERE ARE TWO PERSONALITIES involved in the manuscript.

1. Viddaṇācārya (or Dakṣiṇācārya),

1 The epoch for these texts is the beginning of the current Kaliyuga, i.e., 6 a.m. at Laṅkā on 18 February 3101 BCE.

2 NCC: v. 29, 105 cites four manuscripts. Pingree (1981: 48–9) briefly characterizes the *Vārṣikatantra* and its genre and mentions two surviving manuscripts of the work, one at Harvard (fragmentary) and one at Bikaner (probably Anup Sanskrit Library no. 4411).

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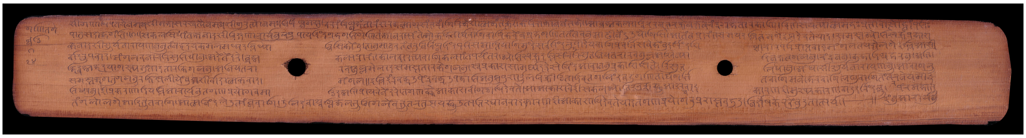

Figure 1: Cover page of the manuscript; at the left top corner the name *Gaṇitagannaḍi* is written; the number 74-1 corresponds to the folio number. Photograph © the author.

2. Śaṅkaranārāyaṇa Jōisaru (son of Demaṇa Jōisaru).[3]

The manuscripts were obtained from the collection of Kulapati Śaṅkaranārāyaṇa Jōisaru (1903–1998) who was the head of the *Sadvidyā Sañjīvinī Pāṭhaśālā*, or School for Enlivening True Learning, at Śṛṅgerī in South India. Kulapati Śaṅkaranārāyaṇa Jōisaru was a descendant of the second author mentioned above and the maternal grandfather of one of the authors of this paper, Seetharam Javagal. The lineage produced well known scholars in the astral sciences (*jyotiṣa*). In particular, a father-son duo of Demaṇa Jōisaru and Śaṅkaranārāyaṇa Jōisaru, who flourished in the latter half of sixteenth century CE, were eminent scholars and wrote commentaries on some of the *jyotiṣa* treatises (*grantha*s) available at that time. The commentaries are in Sanskrit and Kannaḍa and are transmitted on palm-leaf manuscripts in the *Nandināgari* script (see Fig. 1). These palm-leaf manuscripts have been preserved in the family over a period of four hundred years. They are presently, in the keeping of Shri Joshi Shivadatta , son of Kulapati Śaṅkaranārāyaṇa Jōisaru, in Bangalore.

One of the bundles in the collection of palm-leaf manuscripts contains texts on Siddhānta *jyotiṣa* treatises. They are:

1. *Grahaṇamukura* A treatise on eclipses by Demaṇa Jōyisaru son of Devaru Jōyisaru.[4]
2. *Tantradarpaṇa* A commentary on Viddaṇācārya's *Vārṣikatantra* in Sanskrit. Composed in 1601 by Śaṅkaranārāyaṇa Jōisaru, son of Demaṇa Jōyisaru.[5]
3. *Karaṇābharaṇa* A commentary on the *Karaṇaprakāśa* by Brahmadeva (fl. 1092),[6] in Sanskrit. Composed in 1603 by Śaṅkaranārāyaṇa Jōisaru.[7]
4. *Gaṇitagannaḍi* A commentary on Viddaṅacārya's *Vārṣikatantra* in Kannaḍa. Composed in 1604 by Śaṅkaranārāyaṇa Jōisaru.[8]
5. *Grahaṇaratna* Composed by Śaṅkaranārāyaṇa Jōisaru. Date not known.[9]

3 "Jōisaru" is the Kannaḍa version of Sanskrit *Jyotiṣī*, "astronomer." See the family tree, p. 32 below.

4 NCC: v. 6, 249b.

5 Cf. NCC: v. 8, 89a, v. 28, 168a.

6 CESS: A4, 257–8, A5, 240.

7 NCC: v. 8, 89a.

8 Cf. NCC: v. 8, 89a, v. 28, 168a.

9 Cf. NCC: v. 6, 249b.

Figure 2: The inscription stating the award of grants to the astronomers Demaṇa and Śaṅkaranārāyaṇa Jōisaru. Photograph © the author.

In the above manuscripts 2, 3 and 4, the name of the author is given as Śaṅkaranārāyaṇa Jōisaru, and his place, his father's name and the year of copying the manuscript are recorded in the colophons.[10]

Demaṇa Jōyisaru prepared a copy of the *Jātakālaṅkāra*, authored by Sūryadeva Yajvan (b. 1191) of Cōladeśa, with the concluding verse written partly in Sanskrit and partly in Kannaḍa as follows:[11]

> इति श्रीसूर्यदेवसोमसुद्विरचितश्रीपतिपद्धतिव्याख्याने जातकालंकारे प्रकीर्णकाध्यायोऽष्तमः ।
> इति सम्पूर्णः जातकालंकारः। स्वस्तिश्रीजयाभ्युदय शालिवाहनशके
> ೧೫೨೯ ನೇ ಪಲವಂಗ ಸಂವತ್ಸರದ ಮಾಘ ಶುದ್ಧ | ಶುಕ್ರವಾರದಲ್ಲಿ ಸಿಂಗೇರೀ ದೇವರು
> ಜೋಯಿಸರ ಮಗ ದೇಮಣ ಬರದ ಜಾತಕಾಲಂಕಾರದ ಪುಸ್ತಕಕ್ಕೆ ಮಂಗಲ ಮಹಾ
> ಶ್ರೀಶ್ರೀಶ್ರೀ|| ಶುಭಮಸ್ತು ||

This concluding statement in Kannaḍa states that the book *Jātakālaṅkara* was written by Demaṇa, son of Devaru Jōyisaru of Śṛṅgeri, the date of completion being *Śālivāhana śaka* 1529, *Plavaṅga saṃvatsara*, *Māgha śuddha prathama śukravāra*, i.e., Friday 18 January, 1608 CE.

There is another independent document which throws light on the dates and appreciation of the scholarship of this father-son duo. *Epigraphia Carnatica* mentions a stone inscription at Śṛṅgerī.[12] Sri Abhinava Nṛsiṃha Bhārati, the twenty-fourth pontiff (*pīṭhādhipati*) of Śṛṅgerī, established a land grant (*agrahāra*) called Nṛsiṃhapura, near Sṛngeri, and had granted the land revenues to the learned scholar (*mahājanā*s) of various family lineages (*gōtra*s and *sūtra*s). The

10 There is one palm-leaf in the same

land grant is dated *śālivahana śaka* 1525 (1603 CE), *śōbhakṛt, Bhādrapada, śuddha daśamī* (Sunday). This stone inscription is preserved in one of the *adhiṣṭhānam*s in the Śṛṅgerī monastery premises (see Figure 2). This inscription mentions Śaṅkaranārāyaṇa Jyotiṣa, son of Demaṇa Jyotiṣa, in the list of the awardees.

Gaṇithagannaḍi mentions the name of the author at the end of every chapter. The last chapter mentions two additional titles which were probably awarded during the course of writing. The script, as mentioned earlier, is *Nandināgarī*.[13]

2 DESCRIPTION OF THE TEXT

A COMMENTARY ON THE VĀRṢIKATANTRA is documented by Dikshit (1981). He obtained the a manuscript of the text in Sholapur, Maharashtra, with no indication of the name of the commentator. He noted that the calculations were for 1634 and the longitudinal and latitudinal corrections (*deśāntara and palabhā*) corresponded to a place thirteen *yojana*s (150–180 km) west of a hill called Kārtika Parvata (its identity cannot be established). He deduced that the commentator belonged to Dharwad and the text was very popular in Karnataka. The citation of *Grahalāghava* (dated 1520 CE, Balachandra Rao and Uma (2006), Pingree (CESS: A2, 94)) leads one to conclude that *Vārṣikatantra* was written in the sixteenth century at the latest.[14]

The text *Tantradarpaṇa* is a commentary in Sanskrit on *Vārṣikatantra*, while the *Gaṇitagannaḍi* (1604 CE) has a Kannada commentary along with the Sanskrit verses. Although the total number of verses in the two texts differs in some chapters, the original text can be partly reconstructed. (See Appendix for an attempt)

The first chapter of the text *Gaṇitagannaḍi*, called *Dhruvādhikāra*, has 19 verses. But some extra lines are introduced in the *Tantradarpaṇa*, offering still more detailed explanation. Both the texts give a long introduction and the family history of the great teacher Viddaṇācārya whose father Mallaṇācārya also was a great scholar.[15] The text was called *Vārṣikatantra*, "Annual System," by Viddaṇācārya since it was applicable for one whole year and fresh calculations needed to be done for the beginning of every year.

The procedure for deriving the accumulated days (*ahargaṇa*) starting from the Kali-epoch year (*Kalivarṣa*) count is the content of the first chapter. The

bundle that states that Liṅga Jōisaru, the son of the author, paid money (12 gadyana) to the grandson of another person (probably the scribe) in the year 1652 CE. Cf. the family tree, p. 32 below.

11 Pingree 1981: 89 noted that Sūryadeva composed his work in Gaṅgāpura in ca. 1250.

12 Rice et al. 1903: v. 11, 348.

13 One of the present authors (SJ) learnt the script (Visalakshy 2003) and transliterated the manuscript text into Unicode.

14 Pingree (1981: 48–49) dates the work to a period before 1370.

15 NCC: v. 29, 105 calls the father Mallapa.

same chapter has another section called *Grahamadhyādhikāra*, which provides the method for getting the mean positions for planets.

The second chapter has 23 and 19 verses and the extra lines in *Tantradarpaṇa* add to the explanation. This is called *Grahasphuṭādhikāra* and provides the method for deriving the true positions of all planets, perigees and the nodes.

The third chapter is called *Cāyadhyāya* has 19 and 17 verses and describes basically the procedures of the three-question section (*tripraśnādhikāra*) from the *Sūrya Siddhānta*.

The fourth chapter, called *Sōmasūryagrahaṇa*, is devoted to eclipses, the first section on lunar (20 verses) followed by solar eclipse calculations (6 verses).

The fifth chapter called *Parilekhana* (10 verses) describes the graphical method for obtaining the timings, magnitude and points of ingress.

The subsequent chapter is named *Pathādhyāya* (10 verses) and the ones following it have not been given a title. The seventh chapter discusses the helical rising and setting of planets and has 11 verses. This is followed by the conjunction of planets and stars and the conjunction of planets (10 verses).

The eighth and last chapter on *Śṛṅgonnati*, the elevation of the cusps of the moon has 7 verses.

3 UNIQUENESS OF THE TEXT

THE CONTENTS FOLLOW THE GENERAL GUIDELINES OF SIDDHĀNTIC TEXTS. The author declares that he is making a humble attempt to reduce the number of steps in the calculation. He explains the procedure in very crisp sentences in Kannaḍa.

We now describe the method of getting the *ahargaṇa*s and *dhruva*s for a given epoch. It may be recalled that all texts, including the *Siddhāntaśirōmaṇi*, give the rationale based on the *Sūryasiddhānta*. In the other texts like the *Karaṇakutūhala* and the *Grahalāghava* that were more commonly used by later authors, *ahargaṇa*s are calculated from the epoch of Bhāskara's *Siddhāntaśirōmaṇi* and the *dhruva*s provided therein are used for extrapolating the positions of the planets. The number of years from the epoch are calculated and converted to solar months. Subsequently they are converted to lunar months by adding the requisite number of intercalary months (*adhikamāsa*s) and subtracting the number of lost lunar days to be deducted (*kṣayatithi*s) as specified in earlier texts. We will see now the uniqueness in this step as explained by the author himself.

Gaṇeśa Daivajña, in his *Grahalāghava*,[16] simplifies the procedure by adopting a cycle of 4016 years which results in no reminder or integral multiple of the number of revolutions. The *Gaṇakānanda*, a fifteenth-century text in Telugu modifies the procedure slightly to count tropical days instead of *ahargaṇa*s.[17] Another text

16 Balachandra Rao and Uma 2006.

17 Padmaja et al. 2019.

by *Chikkaṇṇa* (early twentieth-century text in Kannaḍa) uses a cycle of 19 years similar to the metonic cycle.

In our text, *Gaṇitagannaḍi*, the author converts the number of Kali years into the longitude corrected for precession (*Sāvanadhruva*) directly by multiplying by 1007 and dividing by 800.

> **शाको नवाद्रीन्दु गुणैः समेतः शैलाम्बर व्योम निशाकरघ्नः ।**
> **खखाष्ट भक्तो भृगुवारपूर्वः कल्यादितः सावनको ध्रुवः स्यात् ॥५ ॥**
>
> ಟೀಕಾ | ನವಾದ್ರೀಂದುಗುಣ್ಯೈಃ ಸಮೇತಃ | 3179 | ಇವರ್ರಿಂ ಕೂಡಲು ಪಟ್ಟಥಾ | ಶೈ-ಲಾಂಬರ ವ್ಯೋಮ ನಿಶಾಕರಘ್ನಃ | 1007 ಇವರ್ರಿಂದ ಹೆಚ್ಚ ಗುಣಿಸಲು ಪಟ್ಟಂಥಾ | ಖ ಖಾಷ್ಟ ಭಕ್ತಃ 800 ಇವರ್ರಿಂ ಭಾಗಿಸಲು ಪಟ್ಟಂಥಾ | ಶಾಕಃ | ಅಭೀಷ್ಟ ಶಕ ವರ್ಷವು | ಕಲ್ಯಾದಿತಃ | ಕಲಿಯುಗ ಪ್ರವೇಶವಾದಾರಭ್ಯವಾಗಿ | ಭೃಗುವಾರಪೂರ್ವಃ | ಶುಕ್ರವಾರಾದಿ-ಯಹಂಥಾ | ಸಾವನಕೋ ಧ್ರುವಃ | ಸಾವನ ಧ್ರುವವು | ಸ್ಯಾತ್ | ಅಹುದು ||
>
> The *śaka* year, added with 3179, (*nava adri indu guṇa*) multiplied by 1007 (*śailambara vyōma niśākara*) and divided by 800 (*kha kha aṣṭa*), becomes the Kali year number for the desired year. It is the *Savana* count for *Dhruvaka* beginning from a Friday (*Bhṛguvāra*).

The rationale is given as follows:

> || ಶಾಕಃ ಯೆಂದರೆ ತನಗಿಷ್ಟವಾದ ಶಕವರ್ಷ | ಆ ಶಕವರ್ಷಾನಯನ ವೆಂತೆಂದರೆ | ನತಿಃ ಶರಘ್ನಾ ಪಾಪೋನಾ ಪ್ರಭವಾದ್ಯಬ್ದ ಸಂಯುತಾ | ಶಕಾಬ್ದಾಃ ಯೆಂದು 60 ನಿಕ್ಕಿಕೊಂಡು 25 ರಿಂ ಗುಣಿಸಿ | ಅಲ್ಲಿ ಹಂನೊಂದ (11) ಕಳದು ಪ್ರಭವಾದಿ ಸಂದ ವರ್ಷ ಸಂಖೆಯಂ ಕೂಡಲು ಶಕವರ್ಷವಹುದು || ಈ ಪ್ರಕಾರದಿಂದ ತಂದ ಅಭೀಷ್ಟ ಶಕವರ್ಷ ವನಿಕ್ಕಿಕೊಂ-ಡು ನವಾದ್ರೀಂದು ಗುಣಾ ಯೆಂಬ (3179) ಇವಂ ಕೂಡಲು ತಾನೊಡುವ ಸಂವತ್ಸರಕೆ ಕಲ್ಯಾದಿಯಾಗಿ ಸಂದ ಕಲಿವರ್ಷವಹುದು |
>
> ಆ ಕಲಿವರ್ಷವನಿಕ್ಕಿಕೊಂಡು ಶೈಲಾಂಬರವ್ಯೋಮನಿಶಾಕರಾ ಯೆಂಬ (1007) ಇವರ್ರಿಂ ಗುಣಿಸಿ ಖಖಾಷ್ಟ ಯೆಂಬ (800) ಇವರ್ರಿಂ ಭಾಗಿಸಲು ಬಂದವು ವಾರ | ನಿಂದ ಶೇಷಮಂ 60 ರ್ರಿಂ ಗುಣಿಸಿ 800 ರಿಂ ಭಾಗಿಸಿ ಬಂದವು ಘಳಿಗೆ | ನಿಂದ ಶೇಷವಂ 60 ರಿಂ ಗುಣಿಸಿ 800 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧವೇ ವಿಘಳಿಗೆ | ಆ ಮೊದಲು ಬಂದ ವಾರಸ್ಥಾನಮಂ 7 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧವಂ ಬಿಟ್ಟು ನಂದ ಶೇಷ ವೇ ವಾರ | ಇಂತು ವಾರ ಘಟಿಕಾ ವಿಘಟಿ-ಕಾತ್ಮಕ ವಹಂಥಾ | ಕಲಿಯುಗೋತ್ಪತ್ತಿ ಸಮಯವಾರಭ್ಯವಾದ | ಶುಕ್ರವಾರಾದಿಯಾದ ಸಾವನ ಧ್ರುವವಹುದು | ಸಾವನ ಧ್ರುವವೆಂದರೆ ಸೂರ್ಯಗೆ ತಂನ ಮಧ್ಯಗತಿಚಾರದಿಂದ ಭಗಣ ಪೂರ್ತಿಯ ಸಮಯಕ್ಕೆ ಬಂದ ವಾರಾದಿಯಹುದು ||
>
> The *śaka* means the year of interest for calculation. *śakānayana* means the count starting from *Prabhava* in the 60 year cycle of *samvatsarā*s. Multiply 60 by 25 and subtract 11; Now add the serial number of the desired *śaka* which now should be added to 3179 to get the *Kali* year

count. This should be multiplied by 1007 and divided by 800. The quotient is the *vāra* count. The reminder should be multiplied by 60 and divided by 800 to get *ghaḷige*; the remainder of this should be multiplied by 60 and divided by 800 to get *vighaḷige*. The *vāra* count earlier obtained should be divided by 7; the quotient is not relevant, the reminder is *vāsara* and its fraction. Thus we got the *vāsara/ghatikā/vighatikā*. This is the *sāvana dhruva* starting from the Kali epoch.

ಈ ಗಣಿತೋತ್ಪತ್ತಿಯ ವಾಸನೆಯೆಂತಂದರೆ | ಶ್ರೀ ಸೂರ್ಯಸಿದ್ಧಾಂತದಲಿ ನಿರೂಪಿಸಿದ ಯುಗ ರವಿ ಭಗಣಂಗಳು 4320000 ನಾಲ್ವತ್ತಮೂರ್ರು ಲಕ್ಷವೂ ಇಪ್ಪತ್ತು ಸಾವಿರ | ಇಂನು ಯುಗಸಾವನದಿನಂಗಳು 1577917828 ನೂರೈವತ್ತೇಳು ಕೋಟಿಯೂ ಯೆಪ್ಪತ್ತೊಂಭತ್ತು ಲಕ್ಷವೂ ಹದಿನೇಳು ಸಾವಿರದ ಯೆಂಟು ನೂರ ಇಪ್ಪತ್ತೆಂಟು | ಇವಂ ಮುಂನ ಪೇಳಿದ ಭಗಣಂದಿಂ ಭಾಗಿಸಲು ಬಂದ ವಾರಾದಿ 365 | 15 | 31 | 31 | 24 ಇಲ್ಲಿಯೂ ವಾರಸ್ಥಾನಮಂ 7 ರಿಂ ಭಾಗಿಸಲು ನಿಂದ ಶೇಷ ವಾರ 1 ಘಳಿಗೆ 15 ವಿಘಳಿಗೆ 31 ಪರೆ ತತ್ಪರೆ 24 ಇವಂನಿ ರ ವ ಯ ವ ವಾರವಾಗಬೇಕೆಂದು ಇಚ್ಛಾಕಲ್ಪಿತಾಬ್ದವಾದ 800 ರಿಂ ಗುಣಿಸಲು ಕ್ರಮದಿಂದ ವಾರ 800 ಘ 12000 ವಿಘ 24800 ಪರೆ 24800 ತತ್ಪರೆ 19200 ಇಷ್ಟು | ಈ ಕೆಳಗಣ ಪ್ರತಿಯಂ 60 ರಿಂದೆತ್ತಲು ಬಂದ ಲಬ್ಧ 320 ಅಲ್ಲಿ ಶೇಷವಿಲ್ಲ ಇವಂ ಮೇಲಣ ಪ್ರತಿಯೊಳು ಕೂಡಲು 25120 ಇಷ್ಟು || ಇವಂ 60 ರಿಂದೆತ್ತಲು ಲಬ್ಧ 418 ಅಲ್ಲಿನಿಂದ ಶೇಷ 40 ಆ ಲಬ್ಧವಂ ಮೇಲೆ ಕೂಡಲು 25218 ಇಷ್ಟು ಇವಂ 60 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧ 420 ನಿಂದ ಶೇಷ 18 ಆ ಲಬ್ಧವಂ ಮೇಲೆ ಕೂಡಲು 12420 ಇಷ್ಟು ||

ಇವಂ 60 ರಿಂದೆತ್ತಲು ಬಂದ ಲಬ್ಧ 207 ಶೇಷವಿಲ್ಲ | ಈ ಲಬ್ಧವಂ ಮೇಲಣ ಪ್ರತಿ 800 ಇವನ್ನೊಡನೆ ಕೂಡಲು 1007 ಇಷ್ಟು | ಇದೀಗ ಶೈಲಾಂಬರವ್ಯೋಮನಿಶಾಕರ ಯೆಂಬ ಸಂಖೆ | ಖಖಾಷ್ಟ ಯೆಂಬುದು ಇಚ್ಛಾಕಲ್ಪಿತಾಬ್ದವೆಂದು ಮೊದಲೇ ಹೇಳಲ್ಪಟ್ಟಿತು | ಇಲ್ಲಿ ಯೆಂಟು ನೂರು ವರ್ಷಕ್ಕೆ ಸಾವಿರದಯೇಳು ವಾರವಾದರೆ ಇಷ್ಟವರ್ಷಕ್ಕೆ ಯೆಷ್ಟು ವಾರವೆಂಬುದು ತ್ರೈರಾಶಿಕ ಗಣಿತ ಅಲ್ಲಿ 800 ರಿಂದ ಗುಣಿಸಿ ಕಳೆಯೇರಿಸುವಾಗ ವಿಘಳಿಗೆಯ ಸ್ಥಾನದಲ್ಲಿ ಮಿಕ್ಕ ಶೇಷ 18 ಪರೆಯ ಸ್ಥಾನದಲ್ಲಿ ಮಿಕ್ಕ ಶೇಷ 40 ಇವಂ ಮತ್ತೆ ಇಚ್ಛಾಕಲ್ಪಿತಾಬ್ದ 2571 ಇವರಿಂ ಗುಣಿಸಿದರಾದ ರಾಶಿ 46278 ಕೆಳಗೆ 102840 ಇವಂ 60 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧ 1714 ಇವಂ ಮೇಲೆ ಕೂಡಲು 47992 ಇವಂ 800 ರಿಂ ಭಾಗಿಸಲು ನೂರರೊಳಗೊಂದಂಶ ಕಡಮೆಯಾದ ವೊಂದು ಘಳಿಗೆ ಬಂತು |

ಅದು ಕಾರಣ ಈಗ ತಾನು ಕಲ್ಪಿಸಿದ ಗಣಿತ ನ್ಯಾಯದಿಂದ ಧ್ರುವವಂ ತರಲಾಗಿ ಯೆಂಟು ನೂರು ವರ್ಷಕ್ಕೆ ಹದಿನೆಂಟು ವಿಘಳಿಗೆಯೂ ನಾಲ್ವತ್ತು ಪರೆಯೂ ಮಿಕ್ಕದರಿಂದ | ಯೆರಡು ಸಾವಿರದ ಐನೂರ ಯೆಪ್ಪತ್ತೊಂದು ವರ್ಷಕ್ಕೆ ವೊಂದು ಘಳಿಗೆಯನು ಧ್ರುವದ ಘಳಿಗೆಯಲ್ಲಿ ಕೂಡಬೇಕು ಯೆಂಬುದರಿಂದ ಮುಂದೆ ರೂಪದ್ರಿ ತತ್ರೈಃ ಯೆಂದು ಕಲ್ಪಿಸಿ ಬೀಜಸಂಸ್ಕಾರವ ಮಾಡಿದನು || ಇಂತು ಸಿದ್ಧಾಂತ ಜ್ಞಾನದಿಂದ ಹಿರಿಯರ ಉಪದೇಶ ಬಲದಿಂದಲೂ ತನ್ನ ಬುದ್ಧಿಯ ಊಹಾಪೋಹ ಬಲದಿಂದಲೂ ಗಣಿತೋತ್ಪತ್ತಿ ವಾಸನೆಗಳನರಿತು ಕೊಂಬುದು ||

Now the rationale of the procedure is being explained.

The explanation of this mathematical procedure is: The number of revolutions of the sun as stated in *Śrī Sūryasiddhānta* is forty three lakhs twenty thousand (43, 20, 000). The number of civil days in a *yuga* is one hundred fifty seven crores, seventy nine lakhs, seventeen thousand, eight hundred twenty eight (157,79,17, 828). When this is divided by the revolution number stated earlier, we obtain in day-count (*vārādi*),

365|15|31|31|24

In this also, upon division by 7, the remainder is day 1, *ghaḷige* 15*vighaḷige* 31, *pare* 31, *tatpare* 24. To make them remainder less (*nirayava*) days, when it is multiplied by the desired-imagined number 800, then, this much in order: day 800, *ghaḷige* 12000, *vighaḷige* 24800, *pare* 24800, *tatpare* 19200. When the lowest [number] in the series is divided by 60, the quotient is 320, there is no remainder. When this (the quotient) is added to the number above, then this much: 25120. When this is divided by 60, the quotient is 418 and from that, the remainder, 40. When the quotient is added to the number above, this much : 25218. When this is divided by 60, the quotient is 420, and the remainder is 18. When the quotient is added above, this much: 12420. When this is divided by 60, the quotient is 207, no remainder. When this quotient is added to the number above, [namely] 800, this much: 1007. This is the number [expressed as] "*śailāmbaravyomaniśākara*".[18] It has already been stated that 800 (*khakhāṣṭa*) is the desired or imagined number of years. Here, the rule-of-three computation: if 1007 days correspond to 800 years, how many [days] for the desired year[-count]. There, when we multiply by 800 and move to the upper place, there is a remainder of 18 at the place of *vighaḷige*, and a remainder of 40 at the place of *pare*. When these are multiplied by the desired-imagined number of years, 2571, then we obtain 46278 [at the place of *vighaḷige*]. Below [at the place of *pare*]; 102840. When this is divided by 60, the quotient is 1714. When this is added to the [number at the] place above, 47992. When this divided by 800 we obtain 1 *ghaḷige* less by one-hundredth part of itself.

The reason is as follows. As eighteen *vighaḷige* and forty *pare* were remaining from the mathematical procedure devised by him for finding the *dhruva*, which implies that one *ghaḷige* has to be added for [every] two thousand five hundred and seventy one [2571] years in the *dhruva*, [the author] devised a correction (*bīja saṃskāra*) [expressed as] "*rūpādri tattvaih*" . Thus, the mathematical explanations

18 *śaila* = mountain (7), *ambara* = sky (0), *vyoma* = space / sky (0) *niśākara* = moon (1).

> should be understood from the knowledge of the *siddhānta*s, from the power of the discourse of the elders, and the imaginative power of [one's own] intellect.

Note that the word *vā* used here means *vāsara* "a civil day;" *vāra* is also the word for the seven day week. For this reason we explicitly specify the word as *vāsara*.

The conversion is done as follows:

19200 *tatpare* means 320 *pare* (obtained by dividing by 60)

This is added to *pare* count 24800 + 320 = 25120

This is converted to *vighaḷige*, after dividing by 60 as 418 (reminder 40 is not used)

418 is added to *ghaḷige*, to get 24800 + 418 = 25218 *ghaḷige*s in all.

The quotient is 420 (reminder 18 is not used) is added to *ghaḷige*, count 12000 to get 12420 *ghaḷige*s.

This is divided by 60 to get *vāsara*s as 207 (no reminder)

Thus total number of *ghaḷighe*s is 800 + 207 = 1007.

This means for 800 years 1007 *vāsara*s (days) need to be added.

We may now understand the rationale in today's terminology:

The duration of the year gets converted 365.258745 days

There are 52 weeks in a year; taking this out we have reminder as 1.258745 days.

This is to be added every year.

If the number of years is n from the epoch, $n \times 1.25875$ should be added.

We can clearly see that 1.258745 is equal to 1007/800; therefore, we need to add $n \times 1007/800$.

Therefore one can see that this entire procedure is to calculate the correction with integers.

The duration of the year is taken to be 364 + (1007/800) days, in the first instance.

There are 52 weeks in a year; taking $52 \times 7 = 364$ out, we have the remainder as (1007/800) days.

This is to be added every year. If the number of years is n from the epoch, $n \times (1007/800)$ should be added. Therefore, one can see that this entire procedure is to calculate the correction with integers.

Now the duation of the year is actually

$$365\ d|\ 15\ |31|31|24$$

according to the *Sūryasiddhānta* followed by the author. The author has explained how one gets 364 + (1007/800) as an approximation to this. In that process, there are remainders at two steps, namely, the remainder 40 while converting from *pare* to *vighaḷige*, and the remainder 18 while converting from *vighaḷige* to *ghaḷige*, which were ignored while finding the approximate value. These have to be included. We will now show that when these numbers are multiplied by 2571, the net correction can be rounded off to one *ghaḷige*, without any remainder.

> 2571 × 18 = 46278 at the place of *vighaḷige* 2571 × 40 = 102840 at the place of *pare*. When this is divided by 60, it gives 1714 *vighaḷige*. Hence, the total number of *vighaḷige* is 46278 + 1714 = 47992. This divided by 800 yields 59.99 *vighaḷige*, which is very close to one *ghaḷige*.
>
> This means that for every 2571 years one extra *ghaḷige* has to be added.

This is the other small correction mentioned by the author. The last line refers to the declaration by the author that he devised this idea on his own deduction.

A similar procedure is derived with integers for multiplication and division to get the *dhruva*s for all the planets as explained below. The phrases in the original text are written Devanāgarī script and the corresponding commentary is written in Kannaḍa.

> **भौमो नावेनद्वाग्नि हतात् ख खांगैः।**
>
> ಕುಜ ಧ್ರುವಮಂ ತಹರೆ | ಕಲಿವರ್ಷವನಿಕ್ಕಿಕೊಂಡು ನವೇಂದ್ವಗ್ನಿಯೆಂಬ 319 ರಿಂ ಗುಣಿಸಿ ಖಖಾಂಗೈಃ ಯೆಂಬ 600 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧಂ ಭಗಣ ಶೇಷವಂ 12 ರಿಂ ಗುಣಿಸಿ 600 ರಿಂ ಭಾಗಿಸಿ ಬಂದವು ರಾಶಿ | ಶೇಷವಂ 30 ರಿಂ ಹೆಚ್ಚ ಗುಣಿಸಿ 600 ರಿಂ ಭಾಗಿಸಿ ಬಂದವು ಭಾಗಿ | ಶೇಷವಂ ಷಷ್ಟಿಘ್ನವ ಮಾಡಿ 600 ರಿಂ ಭಾಗಿಸೆ ಬಂದವು ಲಿಪ್ತಿ | ಇಂತು ವಿಲಿಪ್ತಿಯಂ ತಹುದು | ಇದು ಭಗಣಾದಿ ಭೌಮ ಧ್ರುವವಹುದು | ಇಲ್ಲಿ ಸಿದ್ಧಾಂತೋಕ್ತ ಮಹಾಯುಗವಂ ಕುಜ ಭಗಣವಂ 7200 ರಿಂ ಭಾಗಿಸಿಕೊಂಡನು | ಅಲ್ಲಿ ಕುಜ ಭಗಣ ಶೇಷ 32 ಇವಂ ದ್ವಾದಶಘ್ನವ ಮಾಡಲಾದ ರಾಶಿ 384 ಇವಂ ತ್ರಿಂಶದ್ಗುಣಿತ ವ ಮಾಡಲಾದ ಭಾಗಿ 11520 ಇವರಿಂದಾ ಮಹಾಯುಗವಂ ಭಾಗಿಸೆ ಬಂದ ಲಬ್ಧ 375 . ಇದೀಗ ಬೀಜ ಸಂಸ್ಕಾರವ ಮಾಡಿದ ಪಂಚಾದ್ರಿ ರಾಮ್ಯೈಃ ಯೆಂಬ ಛೇದ ||

4 THE PROCEDURE FOR MARS (*KUJA*)

> Now the calculation of number of revolutions for Mars (*Kuja*). Multiply the number of *kali* years by 319 (*nava indu agni*) and divide by 600 (*kha khāṅgaiḥ*). The quotient gives the number of *bhagaṇa*s (revolutions). The reminder is multiplied by 12 and divided by 600 to get *rāśi*. The reminder of this is multiplied by 30 and divided by 600 to get *bhāga*. The reminder of this is multiplied by 60 and divided by 600 to get *lipti* and then reminder of this multiplied by 60 and divided 600 gives *vilipti*.

The rationale for the procedure is as follows :

> The number of revolutions in a *mahāyauga* is 2296832. There are 4320000 years in a *mahāyuga*. Both these numbers are divided by 600 (subsequently also). This means in 7200×600 years, Kuja completes 319×600 revolutions with a reminder of 32. This means its position will be decided by the reminder 32 which when multiplied by 12 (*dvādaśa*) gives *rāśi*s. 384 *rāśi*s correspond to 11520 degrees by multiplying by 30. The *mahāyuga* is divided by this number to get 375 (*pancādri rāma*). This leaves no reminder when divided by 360. Thus all calculations are involving complete cycles. This means for every year the fraction 319/600 of the revolution should be added.
>
> Therefore for n number of years it is $n \times 319/600$.

The number of revolutions in a mahāyuga is 2296832.

$$\frac{2296832}{4320000} = \frac{319 \times 7200 + 32}{600 \times 7200} \tag{1}$$

$$= \frac{319}{600} + \frac{32}{4320000} \tag{2}$$

Now,

$$32/4320000 \text{ revolutions} = \left[(32 \times 360)/4320000\right]^{o} \tag{3}$$

$$= \left[(1)/375\right]^{o} \tag{4}$$

Hence, for Mars (*kuja*), the increase in longitude per year is 319/600 revolution, and a *bīja* of $\left[(1)/375\right]^{o}$ per year.

> बुधोऽग्न्यगघ्ना द्वियदष्टवेदैः || 6 ||
>
> ಬುಧ ಧ್ರುವಮಂ ತಹರೆ | ಕಲ್ಪಬ್ದಮಂ ಅಗ್ನ್ಯಗ ಯೆಂಬ 73 ರಿಂ ಗುಣಿಸಿ | ವಿಯದಷ್ಟ ವೇ-ದೈಃ ಯೆಂಬ 480 ರಿಂ ಭಾಗಿಸಿ ಬಂದವು ಮುಂನಿನಂತೆ ಭಗಣಾದಿ ಬುಧ ಧ್ರುವ ವಹುದು | ಇಲ್ಲಿ ಮಹಾಯುಗವಂ ಭಗಣವಂ 9000 ದಿಂ ಭಾಗಿಸಿ ಕೊಂಡು ಮತ್ತಂ ಭಗಣ ಛೇದದಿಂದ ಅಧಿಕವಾದ ಕಾರಣ ಛೇದದಿಂ ಭಾಗಿಸಿ ಕೊಂಡನು | ಅಲ್ಲಿ ಬುಧ ಭಗಣ ಶೇಷ 60 ಇವರ ರಾಶಿ 720 . ಇದಕೆ ಭಾಗಿ 21600 . ಇದರಿಂ ಮಹಾಯುಗವಂ ಭಾಗಿಸಿ ಬಂದ ಲಬ್ಧ 200 ಇದೀಗ ಬೀಜಾರ್ಧವಾದ ಖ ನಖೈಃ ಯೆಂಬ ಛೇದ ||

THE PROCEDURE FOR DERIVING THE *DHRUVA* OF MERCURY (*BUDHA*)

> The number of years are multiplied by 73 (*agni yaga* – the compound word is *agnyaga*; the meaning of *yaga* for the number 7 is not clear) and divided by 480 (*viyadaśṭa veda*). This is gives the total number of revolutions. The reminder is converted to degrees minutes and seconds as explained earlier. Here the total number of *bhagaṇa*s in

a *mahāyuga* is divided by 9000. The reminder is 60 corresponds to 720 *rāśi* which is equal to 21600 degrees. When the number of years is divided by 21600 the quotient is 200 without any reminder. This explains the multiplication by (73/480).

The number of revolutions in a *mahāyuga* is 17937060.

$$\frac{17937060}{4320000} = \frac{4 + 657060}{600 \times 7200} \tag{5}$$

$$= \frac{4 + (9000 \times 73)}{9000 \times 480} + \frac{60}{4320000} \tag{6}$$

$$= 4 + \frac{73}{480} + \frac{60}{4320000} \tag{7}$$

Now,

$$60/4320000 \text{ revolutions} = \Big[(60 \times 360)/4320000\Big]^{\circ} \tag{8}$$

$$= [(1)/200]^{\circ} \tag{9}$$

Hence, for Mercury (*Budha*), the increase in longitude per year is 73/480 revolution, and a *bīja* of $[(1)/200]^{\circ}$ per year. Here, the integral number of revolutions (4) is ignored.

वियन्नखा खैर्मुनिखांग निघ्नाद्गुरुस्त्रिषड्बाणहतात् ख खांकैः । सितः शनि शैल ख वेद निघ्ना-द्योमा त्रयार्कैर्ध्रुवका भवन्ति ।। 7 ।।

ಟೀಕಾ | ಗುರು ಧ್ರುವಮಂ ತಹರೆ | ಕಲ್ಪಬ್ದವಂ ಮುನಿಖಾಂಗ ಯೆಂಬ 607 ರಿಂ ಗುಣಿಸಿ ವಿಯನ್ನಖಾಶ್ವ ಯೆಂಬ 7200 ಇವರಿಂ ಭಾಗಿಸೆ ಮುಂನಿನಂತೆ ಭಗಣಾದಿ ಗುರು ಧ್ರುವ ವಹು-ದು | ಇಲ್ಲಿ ಯುಗವಂ ಭಗಣವಂ 600 ರಿಂ ಭಾಗಿಸಿ ಕೊಂಡನು | ಭಗಣ ಶೇಷ 20 ರಾಶಿ 240 ಭೋಗಿ

7200 ಇವರಿಂದಾ ಯುಗಾಬ್ದವಂ ಭಾಗಿಸೆ ಬಂದ ಬೀಜಾರ್ಥ ಛೇದ 3600 ಖಖಾಂಗೈಃ ಯೆಂಬುದೀಗ ||

THE PROCEDURE FOR THE *DHRUVA* OF JUPITER (*GURU*)

The number of years are multiplied by 607 (*muni kha aṅga*) and divided by 7200 (*viyannakhāśva*). Here the multiplying number is 600. Both *yuga* and *bhagaṇa* are divided by 600. The reminder 20 corresponds to 240 *rāśi*s or 7200 degrees. There is no remainder.

The number of revolutions in a *mahāyuga* is 364220.

$$\frac{364220}{4320000} = \frac{(607 \times 600) + 20}{7200 \times 600} \tag{10}$$

$$= \frac{607}{7200} + \frac{20}{4320000} \tag{11}$$

Now,

$$\frac{20}{4320000} = \frac{20 \times 360}{4320000}$$

i. e

$$20/4320000 \text{ revolutions} = \left[(20 \times 360)/4320000\right]^{\circ} \tag{12}$$

$$= [(1)/600]^{\circ} \tag{13}$$

Hence, for Jupiter (Guru), the increase in longitude per year is 607/7200 revolution, and a *bīja* of $[(1)/600]^{\circ}$ per year.

> ಶುಕ್ರೋಚ್ಚ ಧ್ರುವವಂ ತಹರೆ | ಕಲ್ಯಬ್ದವಂ ತ್ರಿಷಡ್ಬಾಣ ಯೆಂಬ 563 ರಿಂ ಗುಣಿಸಿ ಖಖಾಂಕೈಃ ಯೆಂಬ 900 ರಿಂ ಭಾಗಿಸಿ ಬಂದದು ಭಗಣಾದಿ ಭೃಗು ಧ್ರುವವಹುದು | ಶುಕ್ರ ಭಗಣ ಶೇಷ ನ್ಯೂನ ಲಿಪ್ತಿ 108 ಇಲ್ಲಿ ಅಂಶ ಗಣಿತ ಮಾರ್ಗ | ಈ ನೂರ ಯೆಂಟರ ವೊಂಭತ್ತರೊಳಗೆ ವೊಂದಂಶ 12 ಇದಂ 5 ರಿಂ ಗುಣಿಸಲಾಗಿ ಅರುವತ್ತು ಲಿಪ್ತಿ | ಅದೇ ವೊಂದು ಭಾಗಿ | ಇಂನು ಶುಕ್ರಗೆ ಹಾರಕವಾದ 900 ಇದರ 9 ರೊಳಗೆ ವೊಂದಂಶ 100 ಇದಂ 5 ರಿಂ ಗುಣಿಸಲಾಗಿ 500 ವರ್ಷಕ್ಕೆ ವೊಂದು ಭಾಗಿಯ ಕಳೆಯಬೇಕೇಂದು ಖಖೇಷುಭಿಃ ಯೆಂದು ಬೀಜ ಸಂಸ್ಕಾರಾರ್ಥವಾದ ಛೇದವ ಮಾಡಿದನು ||

THE PROCEDURE FOR VENUS (*ŚUKRA*)

> The *dhruva* is obtained by multiplying the number of years by 563 (*tri ṣaḍ bāna*) and dividing by 900 (*kha kha aṅka*). This gives the revolutions. The reminder is 108 *lipti.* The fraction 1/9 of this is 12. Multiply this by 5 you get 60 *lipti*. That is 1 *bhāga* (degree) and the divisor used for Venus is 900. The fraction 1/9 of this is 100. Multiply this by 5. Therefore every 500 (*kha kha eṣu*) years 1 degree should be added. This is the rationale for the formulae.

The dhruva *for Venus* (Śukra)

The number of revolutions in a *mahāyuga* is 7022376.

$$\frac{7022376}{4320000} = 1 + \frac{2702376}{900 \times 4800} \tag{14}$$

$$= 1 + \frac{563 \times 4800}{900 \times 4800} - \frac{24}{4320000} \tag{15}$$

Now,

$$24/4320000 \text{ revolutions} = \left[(24 \times 360)/4320000\right]^{\circ} \quad (16)$$

$$= \left[(1)/500\right]^{\circ} \quad (17)$$

Hence, for Venus (*Sukra*), the increase in longitude per year is 563/900 revolution, and a *bīja* of $\left[-(1)/500\right]^{\circ}$ per year, that is, $\left[(1)/500\right]^{\circ}$ must be subtracted. Here, the integral number of revolutions (1) is ignored.

> ಶನ್ಯೈಶ್ಚರ ಧ್ರುವವಂ ತಹರೆ ||
> ಕಲ್ಯಬ್ದವಂ ಶೈಲಖವೇದ ಯೆಂಬ 407 ಇವರಿಂ ಗುಣಿಸಿ ವ್ಯೋಮತ್ರಯಾರ್ಕೈಃ ಯೆಂದು ವ್ಯೋಮತ್ರಯವೆಂದರೆ ಮೂರು ಸೊಂನೆ | ಅರ್ಕ ವೆಂದರೆ 12 | ಈ 12000 ದಿಂ ಭಾಗಿಸೆ ಭಗಣಾದಿ ಶನಿ ಧ್ರುವವಹುದು | ಇಲ್ಲಿ ಶನಿ ಭಗಣವಂ ಯುಗವಂ 360 ರಿಂ ಭಾಗಿಸಿ ಕೊಂಡನು | ಶನಿ ಭಗಣ ಶೇಷ 48 ಇವಂ ರಾಶಿಯ ಮಾಡಲು 576 ಇವಂ ಭಾಗಿಯ ಮಾಡಲು 17280 ಇವರಿಂದಾ ಯುಗವಂ ಭಾಗಿಸಲಾಗಿ ಬಂದುದು 250 . ಇದೀಗ ಖಾರ್ಥಯಮ್ಯೈಃ ಯೆಂಬ ಬೀಜ ಸಂಸ್ಕಾರದ ಛೇದ ||
> ಇಂತು ಚಂದ್ರಾದಿ ಮಂದಾಂತವಾದ ಗ್ರಹರಿಗೆ ಧ್ರುವಂಗಳಹವು ||

THE PROCEDURE FOR SATURN (*ŚANI*

> Multiply the number of Kali years by 407 (*śaila kha veda*) and 12000 (*vyōma traya arka*). This is gives the number of revolutions. The reminder is 48 which means 576 *rāśi*s and also means 17280 degrees. The *yuga* is divided by this number to get 250 as an integer. Hence the correction (the notation is *kha artha yama* – the meaning is not clear). This is the rule.
>
> That completes the procedure for all the planets.

The dhruva *for Saturn* (Śani)

The number of revolutions in a *mahāyuga* is 146568.

$$\frac{146568}{4320000} = \frac{(407 \times 360) + 48}{12000 \times 360} \quad (18)$$

$$= \frac{407}{12000} + \frac{48}{4320000} \quad (19)$$

Now,

$$\frac{48}{4320000} \text{ revolutions} = \left[\frac{48 \times 360}{4320000}\right]^{\circ} \quad (20)$$

$$= \left[(1)/250\right]^{\circ} \quad (21)$$

Hence, for Saturn (Śani) , the increase in longitude per year is 407/12000 revolution, and a *bīja* of $\left[(1)/250\right]^{0}$ per year.

गुणाब्धि निघ्नाद्धुजगः ख खे भैर्विश्वेन्दु निघ्नात् ख ख दिग्भिरुच्चः ।
विनिक्षिपेद्धत्रयमिन्दु मन्दे विशोधयेच्चक्रदलास्तु राहुम् ।। 8 ।।

ರಾಹು ಧ್ರುವವಂ ತಹರೆ ||
ಕಲ್ಯಬ್ದವಂ ಗುಣಾಬ್ಧಿ ಯೆಂಬ 43 ರಿಂ ಗುಣಿಸಿ ಖಖೇಭೈಃ ಯೆಂಬ 800 ರಿಂ ಭಾಗಿಸಿ ಬಂದದು ಮುನ್ನಿನಂತೆ ಭಗಣಾದಿ ರಾಹು ಧ್ರುವವಹುದು | ಇಲ್ಲಿ ರಾಹು ಭಗಣವಂ ಯುಗಾಬ್ದವಂ 5400 ರಿಂ ಭಾಗಿಸಿಕೊಂಡನು | ಭಗಣ ಶೇಷ 38 ಮಹಾಯುಗದಷ್ಟು ವರ್ಷಕ್ಕೆ ಮೂವತ್ತಂಟು 38 ಭಗಣ ಮಿಗಲಾಗಿ ಮೂರು ಲಕ್ಷವೂ ಅರುವತ್ತು ಸಾವಿರ 360000 ವರ್ಷಕ್ಕೆ 38 ರಾಶಿ ಮಿಗವವು ಹಾಗೆ ಹನ್ನೆರಡು ಸಾವಿರ 12000 ವರ್ಷಕ್ಕೆ 38 ಭಾಗಿ ಮಿಗುವವು | ಆ ಹಾಂಗೆ ಇಂನ್ನೂರು ವರ್ಷಕ್ಕೆ 38 ಲಿಪ್ತಿ ಬಹುದಾಗಿ | ಇಷ್ಟವಾದ ಕಲ್ಯಬ್ದವಂ ವಸ್ವಗ್ನಯಃ ಯೆಂಬ 38 ರಿಂ ಗುಣಿಸಿ ಅಬ್ದ ಶತದ್ವಯೇನ ಯೆಂಬ 200 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಿಪ್ತಿಗಳಂ ರಾಹು ಧ್ರುವದೊಳಗೆ ಕೂಡಬೇಕೆಂದು ಬೀಜ ಸಂಸ್ಕಾರವ ಮಾಡಿದನು ||

THE PROCEDURE FOR THE ASCENDING NODE OF THE MOON (*RĀHU*)

Multiply the number of Kali years by 43 (*guṇa abdhi*) and divide by 800 (*kha kha ibha*). The reminder is converted to degrees and its fractions as explained. Here the number of revolutions and the *yuga* years are both divided by 5400. the reminder *bhagaṇa* is 38. For the number of years corresponding to *mahayuga* 38 (*vasu agni*) revolutions are the reminder. Then for 360000 years 38 *rāśi*s will remain. Similarly for 12000 years 38 degrees will remain. For 200 years 38 *lipti* will be the reminder. Therefore I applied the correction as multiplying by 38 and dividing by 200. This should be added to *Rāhu*.

The dhruva *of* Rāhu

The number of revolutions in a *mahāyuga* is 232238.

$$\frac{232238}{4320000} = \frac{(43 \times 5400) + 38}{800 \times 5400} \tag{22}$$

$$= \frac{43}{800} + \frac{38}{4320000} \tag{23}$$

Now,

$$\frac{38}{4320000} = \left[\frac{38 \times 360 \times 360}{4320000}\right] \tag{24}$$

$$= \frac{38}{200} \text{ arcminutes} \tag{25}$$

Hence, for Moon's node (*Rāhu*), the increase in longitude (in a retrograde manner) per year is 407/12000 revolution, and a *bīja* of $\left[(38)/200\right]'$ per year. Apart from the *dhruva* at the beginning of the solar year as calculated above, 6 rāśis = $[180]^{\circ}$ have to be added, as that is the longitude of Moon's node at the beginning of *kaliyuga*. Also, the value computed thus, has to be subtracted from $\left[360\right]^{\circ}$, as the motion of the node is retrograde. These are pointed out later.

ಚಂದ್ರೋಚ್ಚ ಧ್ರುವವಂ ತಹರೆ ||

ಕಲ್ಯಬ್ದವಂ ವಿಶ್ವೇಂದು ಯೆಂಬ 113 ರಿಂ ಗುಣಿಸಿ ಖಖದಿಗ್ಭಃ ಯೆಂಬ 1000 ಸಾವಿರದಿಂ ಭಾಗಿಸಿ ಭಗಣಾದಿ ಚಂದ್ರೋಚ್ಚ ಧ್ರುವ ಬಹುದು | ಮಹಾಯುಗವಂ ಚಂದ್ರೋಚ್ಚ ಭಗಣವಂ 4320 ರಿಂ ಭಾಗಿಸಿದನು | ಭಗಣ ಶೇಷ 43 ಅದರಿಂದ ರಾಹು ಧ್ರುವದ ಬೀಜ ಸಂಸ್ಕಾರದ ಹಾಗೆ ವಹ್ನಿಯುಗಾನಿಲಿಪ್ತಾಃ ಅಬ್ದಶತದ್ವಯೇನ ಯೆಂದು ಬೀಜ ಸಂಸ್ಕಾರವ ಮಾಡಿದನು || ವಿನಿಕ್ಷಿಪೇದ್ಭತ್ರಯಂ ಇಂದುತುಂಗೇ ಯೆಂದು ಚಂದ್ರೋಚ್ಚ ಧ್ರುವದೊಳಗೆ ರಾಶಿಯೊಡನೆ ಮೂರು ರಾಶಿಯಂ ಕೂಡುವದು |

THE PROCEDURE FOR DERIVING THE MOON'S APOGEE (*CANDRŌCCA*)

Multiply the number of Kali years by 113 (*viśva indu*)and divide by 1000 (*kha kha dik*). This gives the number of revolutions of *candrōcca*. The years of *mahāyuga and candrōcca* were divided by 4320. The reminder 43 was converted for 200 years as was done for Rāhu. You have to add three *rāśi*s for *candrōcca*.

The dhruva *of the Moon's apogee* (mandocca)

The number of revolutions in a *mahāyuga* is 488203.

$$\frac{488203}{4320000} = \frac{(113 \times 4320) + 43}{1000 \times 4320} \tag{26}$$

$$= \frac{113}{1000} + \frac{43}{4320000} \tag{27}$$

Now,

$$\frac{43}{4320000} = \left[\frac{43 \times 360 \times 60}{4320000}\right]' \tag{28}$$

$$= \frac{43}{200} \text{ arcminutes} \tag{29}$$

Hence, for Moon's node (*mandocca*), the increase in longitude per year is 113/1000 revolution, and a *bīja* of $\left[(43)/200\right]'$ per year. Apart from the *dhruva* at the beginning of the solar year as calculated above, 3 rāśis = $\left[90\right]^{\circ}$ have to be added, as that is the longitude of Moon's *mandocca* at the beginning of *kaliyuga.*

ಇದೇನು ಕಾರಣವೆಂದರೆ | ಈ ಗ್ರಹಾನಯನ ಕರ್ಮವೆಲ್ಲಾ ಸೃಷ್ಟ್ಯಾದಿಯಾಗಿ ಪ್ರವೃತ್ತವಾದ ಕಾರಣ | ಅಲ್ಲಿ ಸೃಷ್ಟ್ಯಾದಿ ದ್ವಾಪರಾಂತಕ್ಕೆ ಯೆಲ್ಲಾ ಗ್ರಹರಿಗೂ ಭಗಣ ಪರಿಪೂರ್ತಿಯಾಯಿತು | ಚಂದ್ರೋಚ್ಚಕ್ಕೆ ಮೂರು ರಾಶಿ ಮಿಕ್ಕಿತು | ರಾಹುವಿಗೆ ಆರು ರಾಶಿ ಉಳಿಯಿತು | ಅದರಿಂದ ಚಂದ್ರೋಚ್ಚಕ್ಕೆ ಮೂರು ರಾಶಿಯ ಕೂಡಬೇಕಾಯಿತು | ರಾಹುವನು ಆರು ರಾಶಿಯೊಳಗೆ ಶೋದಿಸಬೇಕಾಯಿತು | ರಾಹುವಿಗೂ ಅಲ್ಲಿ ಮಿಕ್ಕ ಆರು ರಾಶಿಯ ಕೂಡದೆ ಆರು ರಾಶಿಯೊಳಗೆ ಶೋದಿಸಲೇಕೆಂದರೆ | ರಾಹು ಪ್ರತಿಲೋಮಗತಿಯವನಾದ ಕಾರಣ | ಅಲ್ಲಿ ಆರು ರಾಶಿ ಮಿಗದೆ ಭಗಣವೇ ಪೂರ್ತಿಯಾಗಿ ಹರಿದು ಹೋಗಿದ್ದರೂ ಅಲ್ಲಿಂದಿತ್ತ ಬಂದ ಫಲವ ಚಕ್ರ ರಾಶಿ 12 ಇವರೊಳಗೆ ಶೋಧಿಸಬೇಕಾಗುವುದು || ಇಲ್ಲಿ ಮೂರು ರಾಶಿಯೂ ಆರು ರಾಶಿಯೂ ಮಿಕ್ಕವು ಯೆಂಬುದ ಅರಿವ ಉಪಾಯವೆಂತೆಂದರೆ | ಸೃಷ್ಟ್ಯಾದಿ ದ್ವಾಪರಾಂತ್ಯಕ್ಕೆ ಸಂದ ವರ್ಷ 1955880000 ಇವಂ ಕಲ್ಪೋಕ್ತ ಚಂದ್ರೋಚ್ಚ ಭಗಣಂಗಳು 488203000 ಹಾಗೆ ರಾಹು ಭಗಣಂ ಗಳು 232238000 ಇವರಿಂ ಗುಣಿಸಿ | ಕಲ್ಪಾಬ್ದಂಗಳಾದ 4320000000 ಇವರಿಂ ಭಾಗಿಸಲಾಗಿ ಅರಿಯಬಹುದು ||

The reason for this is as follows: For the end of *Dwāpara* (beginning of *Kaliyuga*) all the planets had completed their revolutions exactly. But *candrōcca* and *Rāhu* did not. *Candrōcca* still had to cover three *rāśi*s. *Rāhu* moves in retrograde direction still for completing the zodiac needed 3 more *rāśi*s left. We can get this from the facts the number of years till the end of *dwāpara* 1955880000, The number of revolutions of *candrōcca* 488203000. That of 232238000. Dividing this by the number of years 4320000000 we get the difference.

रूपादरि तत्वैर्विदम्बरार्थैः पञ्चाद्रिरामैः ख नखैः खखांगैः।
ख खेषुभिः खार्थयमैः धृवाणमंशादि बीजस्फुटमब्दराशेः।।

ಕಲ್ಯಬ್ದಮಂ ರೂಪಾದ್ರಿ ತತ್ವೈಃ | ವಿಯದಂಬರಾರ್ಥೈಃ | ಪಂಚಾದ್ರಿ ರಾಮೈಃ | ಖನಖೈಃ | ಖಖಾಂಗೈಃ | ಖಖೇಷುಭಿಃ | ಘಾರ್ಥ ಯಮೈಃ | ಯೆಂಬ ಈ ಪದಕ್ರಮದಿಂದ ಪೇಳಿದ ಯೇಳು ಛೇದಗಳಿಂ ಭಾಗಿಸಿ ಬಂದ ಭಾಗಾದಿಯಂ ಸಾವನ ಧ್ರುವ ಕುಜ ಬುಧ ಗುರು ಶನಿ ಧ್ರುವಗಳೊಳಗೆ ಭಾಗಾದಿಯಲ್ಲಿ ಕೂಡುವದು | ಚಂದ್ರ ಶುಕ್ರರಿಗೆ ಕಳೆಯಬೇಕೆಂದು ಮುಂದೆ ಹೇಳ್ವಿಯಾನು ||

This is summarising the entire procedure.

The total number of years have to be divided by numbers represented by *rūpādri tattva*, *viyadambarārtha*, *pañcādri rāma*, *khakhāṅga*, *khakhaiṣu*, *ghārtha yama* – in that order and the result expressed in degrees minutes and seconds should be added to the *sāvana dhruva* of *Kuja*, *Budha*, *Guru*, *Śani*; for moon and *Śukra* it should be subtracted.

THE PROCEDURE FOR ASCENDING NODE OF THE MOON (*RĀHU*)

वस्वग्नयो वह्नि युगानि लिपता राहौ विधुच्चेब्द शतद्वयेना।
संयोजयेत्बीज फलं धृवेषु वियोजयेद्धार्गाव शीतरश्मियोः।।10।।

ಕಲ್ಯಬ್ದವಂ 38 ರಿಂ ಗುಣಿಸಿ 200 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಿಪ್ತಾದಿಯಂ ರಾಹು ಧ್ರುವಕೆ ಕೂಡುವದು | ಹಾಗೆ ಅಬ್ದವಂ 43 ರಿಂ ಗುಣಿಸಿ 200 ರಿಂ ಭಾಗಿಸಿ ಬಂದ ಲಿಪ್ತಾದಿಯಂ ಚಂದ್ರೋಚ್ಚ ಧ್ರುವದೊಳಗೆ ಕೂಡುವದು | ಇದರೊಳಗೆ ಚಂದ್ರ ಶುಕ್ರರಿಬ್ಬರ ಧ್ರುವಗಳೊಳಗೆ ಬೀಜ ಸಂಸ್ಕಾರ ಫಲವ ಕಳೆಯಬೇಕೆಂಬುದು ರಾಹು ಧ್ರುವಕೆ ಬೀಜ ಸಂಸ್ಕಾರ ಫಲವಂ ಕೂಡಿ ಮತ್ತೆ ಚಕ್ರಾರ್ಧ ಶೋಧನೆಯ ಮಾಡುವದು ||

The number of *Kali* years should be multiplied by 38 and divided by 200 and added to *Dhruva* for *Rāhu*; should be multiplied by 43 and divided by 200 and added to *Dhruva* for *candrōcca*. For the moon and *Śukra* the correction should be subtracted. For *Rāhu*, the *bīja* correction should be added and recalculated successively.

5 DISCUSSION

THE LAST LINE IN THIS CHAPTER CONCLUDES WITH THE FOLLOWING SENTENCE:

ಇವು ಮುಂತಾದ ಧ್ರುವ ಗಣಿತೋತ್ಪತ್ತಿ ಬೀಜ ಸಂಸ್ಕಾರ ಗಣಿತ ವಾಸನೆ ಅದರ ಧನ ಋಣ ಕಾರಣ ಗಳೆಲ್ಲಾ ಅತಿ ರಹಸ್ಯವಾದರೂ ಅರಿತಂಥಾದನೂ ಹೇಳಬೇಕೆಂಬುದರಿಂದ ಸ ರಹಸ್ಯವಾಗಿ ಸ ಪ್ರಪಂಚ ವಾಗಿ ಸ ಮೂಲ ಶಾಸ್ತ್ರಕವಾಗಿ ಹೇಳಿದೆನು ||

Thus all the calculations for *bīja* correction, positive and negative corrections are explained. They appear mysterious but I have explained here completely as per the original texts of the *Siddhānta*.

It is to be noted that the summarising verse includes another phrase for correction called *viyadambarārtha*, which was pointed out by the referee as applicable to the moon. However, both the texts do not contain corresponding verses for the position of the moon. (The Appendix has the compiled text.) In the following chapter on eclipses, the details of the derivation of the position of the moon are described.[19]

It may be seen that the procedures given here are different from those given in other similar texts. Gaṇeśa Daivajña, in his *Grahalāghava*, simplifies the procedure by adopting a cycle of 4016 years which results in no reminder or integral multiple of the number of revolutions.[20] The rationales for deriving the *dhruva*s of all planets are not explained in detail. Chikkaṇṇa, in his *Dṛksiddhāntadarpaṇa*

19 We plan to bring that out in a future publication.

20 Balachandra Rao and Uma 2006.

(another twentieth-century text in Kannaḍa), uses a cycle of 19 years similar to the metonic cycle following the procedure given.[21]

It has been possible to correct the minor errors either typographical or grammatical, since there are two manuscripts available. *Tantradarpaṇa* contains all these verses with commentary in Sanskrit. There are some small differences since the two are written with a time difference of about a year or so. The author has used the same technique in the subsequent texts too.

There is another text by Śaṅkaranārāyaṇa, a commentary on Brahmadeva's eleventh-century *Karaṇābharaṇa*.[22] It is similarly written in the *Nandināgari* script and in Sanskrit.

Demaṇa wrote another text called *Grahaṇamukura* ("The Mirror of Eclipses") wherein the same procedures were adopted.[23] However the explanation or rationale was very brief.

The present text further continues to other chapters on deriving the mean positions, true positions and other calculations on eclipses, heliacal rising and planetary conjunctions. These chapters also have very innovative procedures and will be discussed in forthcoming papers. We also plan to list the word-numbers (*bhūtasaṅkhyā*s) used extensively in the text.

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21 Ketkar 2001.

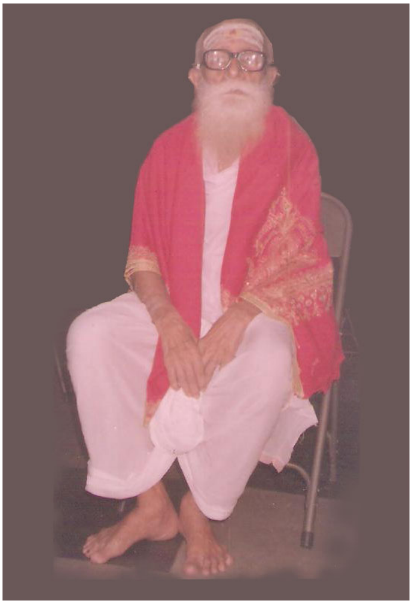
22 Mahesh 2019. Cf. NCC: v. 8, 89a and ˇ. 32, 244b for a MS of Śaṅkaranārāyaṇa's commentary on *Tantradarpaṇa*.

23 NCC: v. 6, 249b.

FAMILY TREE OF ŚAṄKARANĀRĀYAṆA JŌISARU'S ANCESTORS

The following family tree of male ancestors was provided by Seetharam Javagal.

Devaru Joīsaru (probably born after 1500 CE)
|
Demaṇa Jōisaru (jyotiṣa author, fl. 1599–1618 CE)
|
Śaṅkaranārāyaṇa Jōisaru (jyotiṣa author)
|
Liṅga Jōisaru
|
Yallaṇṇa Jōisaru
|
Mahādeva Jōisaru
|
Yallappa Jōisaru
|
Śaṅkaranārāyaṇa Jōisaru
|
Mahādeva Jōisaru
|
Śaṅkaranārāyaṇa Jōisaru
|
Mahādeva Jōisaru
|
Rāmacandra Gaṇeśa Jōisaru
|
Kulapati Śaṅkaranārāyaṇa Jōisaru (1903–1998)



APPENDIX: VERSES FROM VĀRṢIKATANTRA AS FOUND IN THE *GAṆITAGANNAḌI*

As reconstructed from *Gaṇitagannaḍi* (MS 1) and *Tantradarpaṇa* (MS 2). MS variants appear in the footnotes.

FIRST CHAPTER

आब्रह्मकल्पाद्विचरन् भचक्रे नक्षत्रचन्द्रग्रहतारकाणि ।
विभासयत्यात्ममहः प्रभावात्सोह्नां पतिः पातु सदा जगन्ति ॥ १ ॥

अस्ति स्म कौडिन्य मुनिर्मुनीनामग्रेसरो विप्रकुलप्रदीपः ।
त्रयीं[24] निधातुं प्रथमं विधाता यमेकपात्रं प्रथितं चकार ॥ २ ॥

तस्याभिजातः पृथुकीर्तिरग्र्यः प्रभूतविद्यः प्रचुरव्रताढ्यः ।
ज्योतिर्विदां भानुरिवाग्रगण्यो विभासमानो भुवि मल्लणोऽभूत् ॥ ३ ॥

तस्याभवद्विद्दणनामधेयः सूनुः सुधारोचिरिव द्वितीयः ।
सुवृत्तवानुद्दत पित्र्यलोकस्तन्निर्मितं वार्षिकतन्त्रमेतत् ॥ ४ ॥

शाको नवाद्रीन्दुगुणैः समेतः शैलाम्बरव्योम निशाकरघ्नः ।
खखाष्ट भक्तो भृगुवारपूर्वः कल्यादितः सावनको ध्रुवः स्यात् ॥ ५ ॥

विश्वाकृतिघ्नः खखशून्यतर्कैर्ध्रुवः सुधांशोर्भगणादिकः स्यात् ।
भौमो नवेन्द्वाग्नि हतात् खखांगैः । बुधोग्न्यगघ्नाद्वियदष्टवेदैः ॥ ६ ॥

वियन्नखाखैर्मुनिखांगनिघ्नाद्गुरुस्त्रिषड्बाणहतात् खखांकैः ।
सितः शनिः शैलखवेदनिघ्नाद्व्योमत्रयार्कैर्ध्रुवका भवन्ति ॥ ७ ॥

गुणाब्धिनिघ्नाद्भुजगः खखेभैर्विश्वेन्दु निघ्नात् खखदिग्भिरुच्चः ।
विनिक्षिपेद्भत्रयमिन्दुमन्दे विशोधयेच्चक्रदलात्तु राहुम् ॥ ८ ॥

रूपाद्रितत्वैर्वियदम्बरार्थैः पञ्चाद्रिरामैः खनखैः खखांगैः ।
खखेषुभिः खार्थ यमैर्ध्रुवाणामंशादि बीजस्फुटमब्दराशेः ॥ ९ ॥

वस्वग्नयो वह्नियुगानि लिप्ता राहौ विधूच्चेऽब्द शतद्वयेन ।
संयोजयेत्बीजफलं धृवेषु वियोजयेद्भार्गवशीतरश्म्योः ॥ १० ॥

24 विधातुं in MS 2

ABBREVIATIONS

CESS Pingree, D. E. (1970–94), *A Census of the Exact Sciences in Sanskrit*, 5 vols. (Philadelphia: American Philosophical Society), https://archive.org/details/PingreeCESS, (on 9 Mar. 2018).

NCC Raghavan, V., Kunjunni Raja, K., Sundaram, C. S., Veezhinathan, N., Gangadharan, N., Rama Bai, E. R., Dash, S., et al. (1949–), *New Catalogus Catalogorum, an Alphabetical Register of Sanskrit and Allied Works and Authors* (Madras University Sanskrit Series; Madras: University of Madras); v.1: revised edition, 1968.

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