

The *Siddhāntasundara* of Jñānarāja
A Critical Edition of Select Chapters with English Translation and Commentary

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This dissertation by Toke Lindegaard Knudsen is accepted in its present form by
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Biography

Toke Lindegaard Knudsen was born in Køge, Denmark on January 23, 1974, the son of a kindergarten teacher and an engineer. He attended the University of Copenhagen, where he earned a Bachelor of Science degree and a Master of Science degree in Mathematics, and later a Bachelor of Arts degree in Indology. While working towards his Master of Science degree, he felt a desire to broaden the scope of his studies and include the humanities in his study of mathematics. This led him to take a strong interest in the history of mathematics, a topic that he was introduced to while being an exchange student at Monash University in Melbourne, Australia, and he eventually wrote a thesis on mathematical methods in ancient Indian ritual. In order to continue his studies of the mathematics of ancient and medieval India, he began to study Sanskrit at the University of Copenhagen. Finally, his mathematical learning and his knowledge of Sanskrit allowed him to begin a Ph.D. on Indian astronomy in the Department of the History of Mathematics at Brown University. While at Brown University, he has received Fellowships, including a Brown University Dissertation Fellowship, to support his academic pursuits.

Publications

- “House Omens in Mesopotamia and India,” in *From the Banks of the Euphrates: Studies in Honor of Alice Louise Slotsky*, ed. Micah Ross, Winona Lake, Indiana: Eisenbrauns, 2008, 121–133.
- “David Pingree (1933–2005),” *Bulletin of the Canadian Society for History and Philosophy of Mathematics* 38 (May 2006), 5–6.
- Review of François Patte, *L’œuvre mathématique et astronomique de Bhāskarācārya: Le Siddhāntaśiromaṇi* I–II, *Archives internationales d’histoire des sciences* 55 (December 2005), 515–517.
- “Square Roots in the *Śulbasūtras*,” *Indian Journal of History of Science* 40 (2005), 107–111.
- (with Clemency Williams) “South-central Asian science,” *Medieval Science, Technology, and Medicine: An Encyclopedia*, ed. Thomas Glick, Steven J. Livesey, and Faith Wallis, New York and London: Routledge, 2005, 462–465.
- “On Altar Constructions with Square Bricks in Ancient Indian Ritual,” *Centaurus* 44 (2002), 115–126.

Acknowledgements

This dissertation is dedicated to the memory of my mentor

DAVID EDWIN PINGREE (JANUARY 2, 1933–NOVEMBER 11, 2005)

and to the memory of my maternal grandfather

HANS ESPEN POUL HANSEN (JULY 27, 1913–NOVEMBER 11, 1996)

Both taught me so much in their different ways. Both are missed.

Completing a Ph.D. is a joyous occasion, but it is nevertheless with some sadness that I put the finishing touches on this dissertation. My graduation will mark the end of the Department of the History of Mathematics at Brown University, 61 years after it was founded in 1947 and 51 years after the graduation of its first Ph.D. student in 1957. (Incidentally, this first student was Asger Aaboe, a fellow Dane, so the story of the department’s students begins and ends in Denmark.) While I look forward to new challenges, it is an odd feeling to be the one to turn off the light.

Sadly, not long after I reached candidacy, my advisor and mentor, David Pingree, passed away. I am immensely grateful to Dean Sheila Bonde for all the support that she extended to me during the difficult period that ensued, and I am indebted to the members of my committee, Kim Plofker, Christopher Minkowski, Kenneth Zysk, Jan Hogendijk, Peter Scharf, and Sheila Bonde, for stepping in to help me complete my project. I look forward to their continued advice as I grow to become their colleague.

I wish to extend special thanks to John Stillwell for introducing me to the history of Indian mathematics; to Jesper Lützen for encouraging my studies in this field; to Kenneth Zysk for all his continued support; to Kim Plofker for being a friend as well as a teacher; to Alice Slotsky for all her encouragement; to Clemency, Yann, Pierre, and Gabriel Montelle for their friendship which has always made a big difference; to Micah Ross for his friendship; to Sukriti Issar for her patience and support; and to my family for always being there for me. I further extend thanks to Isabelle Pingree, Ramaswamy Chandrashekar, S. R. Sarma, Takanori Kusuba, Michio Yano, Takao Hayashi, Enrica Garzilli, James Fitzgerald, Susan Alcock, Donna Wulff, Deborah Boedeker, and Kurt Raafaub.

That I am not able to present this dissertation to David Pingree, who taught me everything I know about Indian astronomy, fills me with regret. My hope is that he would have been pleased.

*vidvadbhir api duḥsādhyaṃ jyotiḥśāstraṃ munistutam /
sūpadiṣṭaṃ tu toke 'pi yena taṃ naumi deśikam //*

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Chapter 1

Introduction

1.1 General background

Some years ago, in 2000, I corresponded with David Pingree about my plans for combining my background in mathematics with my studies of Sanskrit to do a Ph.D. in Indian mathematics. In that correspondence, Pingree strongly encouraged me to work with Indian astronomy in the medieval period, a subject that I knew nothing about at the time. Confessing my ignorance, I asked him if he could suggest a project that would be suitable for someone with my background. In response, he wrote: “... the Siddhāntasundara of Jñānarāja, the last important siddhānta not to have been published.”¹ A *siddhānta* is the most extensive type of astronomical treatise in the Indian tradition, which includes theory in addition to mathematical algorithms and formulae. The *Siddhāntasundara*, or the Beautiful Treatise, belongs to this category.

Accepting this suggestion was easy. The *Siddhāntasundara* seemed an ideal topic to me in that it would allow me to continue working with Sanskrit manuscripts. I further felt that working through an entire Sanskrit astronomical treatise would be a good way to engage with the tradition in a substantial and comprehensive way.

Now, after nearly six years of immersion in the study of Indian astronomy, I can add many more reasons why the *Siddhāntasundara* was a worthwhile choice. It is estimated that some 30 million Sanskrit manuscript survive, of which at least 10% deal with the exact sciences, which here, following Pingree, are defined broadly to include astrology, various kinds of divination, omens and so on. Only a fraction of this material has been published, and what has been published is often not edited properly. Many of the old editions of important texts, while good, do not draw on all of the manuscripts and commentaries that are available now. As such, much of our knowledge of the history of astronomy in India is based on uncertain conclusions drawn from editions of texts that might have omissions. Preparing a careful edition of an important text is therefore a valuable contribution.

¹Letter from David Pingree dated November 13, 2000.

The *Siddhāntasundara*, as noted by Pingree, has never been edited and published before, and as such making it available to scholars is a contribution in itself. However, there is more to recommend the *Siddhāntasundara* than this.

The *Siddhāntasundara* stands at a unique point in time in the history of Indian astronomy, its composition marking the beginning of what Minkowski calls an early modern period in *jyotiḥśāstra*.² New ideas and perspectives are brought forth in it, and while maintaining tradition, it also breaks from it. The new ideas found in the *Siddhāntasundara* were taken up by writers in the following centuries, and they helped shape the indigenous response to Islamic astronomy.

In this section, a brief overview of the *Siddhāntasundara*, its author, and its historical context will be given, some of which will be continued by more detailed discussions in the following sections.

1.1.1 Jñānarāja, the author of the *Siddhāntasundara*

The *Siddhāntasundara* was composed by Jñānarāja,³ a member of a *brāhmaṇa* family of the Bhāradvāja lineage (i.e., a family belonging to the highest class of Hindu society that traces its ancestry to the ancient sage Bhāradvāja) with a long history of learning and scholarship. Besides brief information given in the *Siddhāntasundara* and in some of the works of his son Sūryadāsa, little is known about his life.

At the end of the *Siddhāntasundara*, Jñānarāja provides us with a genealogy, in which he traces his ancestry back to a man named Rāma, who he says was honored by King Rāmacandra of the Yādava dynasty (r. 1271–1311 CE). Besides their names and that they are said to have been learned men, we know next to nothing about Jñānarāja’s ancestors. Jñānarāja’s father Nāganātha is said by Jñānarāja’s son Sūryadāsa to have been accomplished in *jyotiḥśāstra* (the astral sciences, including astronomy and astrology), and since the same is certainly true for Jñānarāja as well as for his two sons, it appears that there was a tradition of studying astronomy in the family.

We are not told when Jñānarāja lived, nor when the *Siddhāntasundara* was composed. However, an epoch (the precise time used as a reference point for computing planetary positions) corresponding to local sunrise on Friday, September 29, 1503 CE is given in the *Siddhāntasundara*, and Jñānarāja’s son Sūryadāsa writes that he was born in the year 1507 CE or 1508 CE.⁴ This indicates that Jñānarāja flourished around the beginning of the sixteenth century CE and that the *Siddhāntasundara* was composed at that time. This dating is consistent with Rāma having flourished during the reign of King Rāmacandra, as seven generations separate Jñānarāja from his ancestor Rāma.

Jñānarāja lived in a town called Pārthapura (the modern Pathri in the Parbhani District of Maharashtra) by the Godāvarī river near a *tīrtha* (literally, ford; in the Indian tradition, a *tīrtha* is a sacred place where people go for pilgrimage) called Pūrnatīrtha. In his genealogy, Jñānarāja tells

²See [51 . 497].

³The name literally means “king of knowledge”, but is explained as “shining with knowledge” by Jñānarāja’s son Cintāmaṇi in his commentary on his father’s *Siddhāntasundara*.

⁴Sūryadāsa gives the year *śaka* 1430 in the Indian calendar as the year of his birth, which means that he was born in either 1507 CE or 1508 CE.

us that Rāma lived in Pārthapura as well, so the family appears to have been based there for a long time.

1.1.2 Historical background

The Yādavas

Rāma, the first ancestor listed by Jñānarāja in his genealogy, was honored by a Yādava king. The Yādavas were a powerful dynasty that ruled large parts of the Deccan (a large plateau comprising most of Central and Southern India) in the twelfth and thirteenth centuries CE from their capital Devagiri (the modern Daulatabad in Maharashtra), including the area where Jñānarāja's family lived.⁵ The Yādava kings were liberal and generous patrons who provided well for the *brāhmaṇa* teachers of their domain. As such they attracted eminent scholars to their kingdom, where a culture of learning flourished.⁶ This included the study of astronomy.⁷ Lakṣmīdhara, the son of the renowned astronomer Bhāskara II, was the chief counselor of the Yādava king Jaitrapāla (r. 1193–1210).⁸ Lakṣmīdhara's son Caṅgadeva was the court astrologer of Siṅghaṇa II, the successor of Jaitrapāla, and was involved in the establishment of a *maṭha* dedicated to the study of the works of Bhāskara II at Pāṭṇā (note that this is not the modern Patna in Bihar) on August 9, 1207.⁹ Through Rāma, Jñānarāja's family and the scholarship of its members were connected to this general culture of learning that flourished in the Yādava kingdom.

Islamic rule

The Yādavas reached their zenith during the reign of King Rāmacandra. However, even during his reign, Devagiri was sacked twice by forces from the Islamic Sultanate of Delhi, and after his death the Yādava kingdom was annexed by the Sultanate.¹⁰ The area was subsequently ruled by various Islamic dynasties. However, this does not mean that the patronage offered by the Yādavas ended.

In addition to being the ancestral home of Jñānarāja's family, Pārthapura (known as Pāthrī in Islamic sources) is also the ancestral home of the Nizām Shāhīs, the Islamic rulers of the Ahmadnagar kingdom. Ahmad Nizām Shāh (r. 1490–1509 CE), the founder of the Nizām Shāhī dynasty and the Ahmadnagar kingdom, descended from a *brāhmaṇa* family from Pārthapura.¹¹ Pārthapura, however, was governed by the neighboring Islamic kingdom of Berar, and Burhān Nizām Shāh

⁵For a history of the Yādavas, see [103].

⁶See [103 . 231–233, 255–256].

⁷See [103 . 111, 264] and [56 . 196].

⁸See [103 . 184–185] and [65 . A.4.299]. Jaitrapāla is also known as Jaitugi. For the years of his reign, see [103 . 368]. For Bhāskara II, see below, p. 4.

⁹See [103 . 256] and [65 . A.3.39–40]. Caṅgadeva flourished ca. 1200/1220 (see [65 . A.3.39]), and Siṅghaṇa II reigned 1210–1246 CE (see [103 . 368]).

¹⁰See [103 . 147–158, 161].

¹¹See [32 . 3.116, 130], [38 . 398], and [5 . 108].

(r. 1509-1533 CE), Ahmad Nizām Shāh's son and successor, fought a number of battles with Berar over the town starting in 1518.

Little is known about the extent to which the Islamic rulers of the region offered patronage to Hindu scholars or promoted sciences such as astronomy, but they did to some extent; Ahmad Nizām Shāh, for example, was a patron of Hindu writers.¹²

Bhāskara II and his legacy

One of the most renowned figures in Indian astronomy is Bhāskara II (b. 1114 CE).¹³ A number of important astronomical and mathematical works were composed by him, and, as we saw above, descendants of his, who held high positions at the Yādava court, were instrumental in promoting the study of these works, and of astronomy in general.

The most notable astronomical work of Bhāskara II is the monumental *Siddhāntaśiromaṇi*,¹⁴ which was completed in 1150 CE. As a treatise, it is clear and comprehensive, a testimony to Bhāskara II's deep understanding of the subject.

As noted by Pingree, the most impressive quality of the *Siddhāntaśiromaṇi* is its comprehensiveness,¹⁵ a quality that ensured that it (and other of Bhāskara II's works) became normative in the period following him. In fact, after the composition of the *Siddhāntaśiromaṇi* in 1150 CE, the Indian astronomers moved in a didactic direction, focusing on writing commentaries on existing treatises and composing *koṣṭhakas* (astronomical tables meant to facilitate the computation of planetary positions for casters of horoscopes and makers of calendars¹⁶) rather than writing original treatises.¹⁷

A concept central to the work of Bhāskara II is that of *vāsanā*, “demonstration”. A *vāsanā* for an astronomical algorithm or formula is a demonstration of it, i.e., what we can loosely call a proof.¹⁸ Bhāskara II's own commentary on the *Siddhāntaśiromaṇi* is called the *Vāsanābhāṣya* (literally, Demonstration Commentary), and it provides demonstrations for the mathematical algorithms and formulae found in the main text.

¹²See [34 . 159–160].

¹³For Bhāskara II and his works, see [65 . A.4.299–326, A.5.254–263]. He is called the second Bhāskara to avoid confusion with an earlier astronomer of the same name.

¹⁴The edition of the *Siddhāntaśiromaṇi* used here is [87].

¹⁵See [74 . 26].

¹⁶See [71 . 41].

¹⁷See [74 . 26].

¹⁸It should be noted, though, that the Indian tradition does not operate with proofs in the Euclidean sense that we use today.

The eight *siddhāntas*

A group of minor *siddhāntas*,¹⁹ including the *Brahmasiddhānta*, the *Somasiddhānta*, and the *Vasiṣṭha-siddhānta*, were composed during the 350-year period between the composition of the *Siddhāntaśiromaṇi* and the composition of the *Siddhāntasundara*. Each of these treatises has the form of a discourse on astronomy between a deity or a sage (the teacher) and a sage (the student). According to the *Brahmasiddhānta*, there are eight such original discourses, through which the science of astronomy was revealed.²⁰ Thus a tradition arose of an eight-fold origin of astronomy as a revelation by eight divine personages, recorded in these eight astronomical treatises. As revelations by superhuman personages, these eight *siddhāntas* possess divine authority, but they are deficient in one respect: they are not accompanied by *vāsanās*.

1.1.3 The *Siddhāntasundara*

During the period of about 350 years between Bhāskara II composing the *Siddhāntaśiromaṇi* in 1150 CE and the composition of the *Siddhāntasundara* around the beginning of the 16th century CE, no major *siddhānta* was written. In other words, Jñānarāja's *Siddhāntasundara* was the first major *siddhānta* to be written after the *Siddhāntaśiromaṇi*. As pointed out by Minkowski, to write a major astronomical treatise after a long period of time "... is to recuperate the past, but at the same time to break from it..."²¹ What were the elements that Jñānarāja sought to recapitulate, and in which ways did he break from the tradition?

Jñānarāja states directly that the *Siddhāntasundara* is his own rendering of the contents of the *Brahmasiddhānta* to which he has added *vāsanās*.²² One of his aims is therefore to provide *vāsanās* for the texts of eight *siddhāntas*. in particular the *Brahmasiddhānta*, in order to make the tradition more deductive and demonstrative, and thus on a par with the tradition of Bhāskara II. Why he chose the *Brahmasiddhānta*, a somewhat obscure text at his time, as his source is not clear. However, the reason is perhaps to be sought in Jñānarāja's concern with the authority of sacred texts.

In addition to the cosmology of the astronomical tradition, the *purāṇas* (a group of texts considered sacred in Hinduism) present a cosmology as well, one that enjoyed a broader acceptance in the greater Hindu tradition. However, the two cosmologies are not consistent with each other. The general approach to this problem among the Indian astronomers had been to incorporate compatible elements from the cosmology of the *purāṇas* into their own model, while rejecting other incompatible elements.²³ Jñānarāja, however, took a different route. To him the statements of the *purāṇas* could not be contradicted. At the same time, he was working within the framework of the astronomical tradition. His solution was to seek to eradicate the contradictions through reinterpretation of

¹⁹See [74 . 26].

²⁰*Brahmasiddhānta* 1.9–10. The edition used is [21].

²¹See [51 . 498].

²²*Siddhāntasundara* 1.1.3.

²³See [52 . 352–354].

statements from both traditions.²⁴

The *Brahmasiddhānta* stands apart from other astronomical treatises in that in addition to being an astronomical treatise, it also deals with religion; in fact, it contains a whole chapter that reads like a *purāṇa*, which is presumably where the religious material of the text is found.²⁵ It is possible that this was an inspiration for Jñānarāja.

Thus Jñānarāja is bringing the authority of the *purāṇas* into the astronomical tradition, and through additions of *vāsanās* he is ensuring that his treatise meets the standard of the tradition of Bhāskara II. It is also possible that Jñānarāja was reacting to the spread of Islamic astronomy.

Format of the *Siddhāntasundara*

As is the case with all *siddhāntas* and other types of astronomical treatises, the *Siddhāntasundara* is written in verse. A Sanskrit verse is divided into four *pādas* (quarters), referred to as a, b, c, and d, respectively, in the following. The fact that scientific treatises were written in verse, however, does not mean that they can be considered poetry. Phrasing the material in metrical form aids memorization and also serves to preserve the text better; errors in a metrical text are easier to see than errors in prose.

The final section of the *golādhyāya* is an elaborate and complex poem describing the seasons. Here, again, Jñānarāja follows the model of Bhāskara II, who also included such a poem in the *Siddhāntaśiromaṇi*; but Jñānarāja's poem is more than twice as long as that of Bhāskara and more intricate.

An unusual feature of the *Siddhāntasundara* is the sample problems that Jñānarāja have included in the *tripraśnādhikāra* (the section on questions concerning diurnal motion). These are poetic and phrased using double entendre: one level of meaning provides a narrative, the other provides the technical information necessary to solve a given problem.

Contents of the *Siddhāntasundara*

The *Siddhāntasundara* is divided into three chapters:

1. the *golādhyāya*, or the chapter on the sphere,
2. the *grahagaṇitādhyāya*, or the chapter on mathematical astronomy, and
3. the *bījagaṇitādhyāya*, or the chapter on algebra.

Each chapter is further divided into a number of sections.

The *bījagaṇitādhyāya*, while a legitimate part of the *Siddhāntasundara*, stands apart in that it has been handed down separately in the manuscript tradition. This is presumably because it deals

²⁴See [52 . 351–354]. See also “The issue of *virodhāparihāra*” on p. 49 in section 1.3.7.

²⁵See [22 . 2.49]. Unfortunately, Dikshit does not specify what sort of religious matters the text deals with, and Dhavale, the editor of the critical edition of the *Brahmasiddhānta*, chose not to include the *purāṇa*-like chapter in his edition, as he felt that its subject matter did not justify its inclusion in a treatise on astronomy (see [21 . ix]).

with a different topic (pure mathematics) than the other two chapters. For these reasons, it has often been taken as a separate work in the secondary literature. The *bījagaṇitādhyaṃya* has not been the subject of any study here.

The division of the astronomical part of the *Siddhāntasundara* into a *golādhyaṃya* and a *graha-gaṇitādhyaṃya* follows the same division as that found in the *Siddhāntaśiromaṇi* of Bhāskara II.²⁶ It separates two subjects:

1. mathematical astronomy, which provides algorithms and formulae for computing planetary positions, eclipses, and so on, and
2. spherics, which undertakes to explain the model on which the algorithms and formulae are based.

While this basic division is there in both the *Siddhāntaśiromaṇi* and the *Siddhāntasundara*, the order is different. The published editions of the *Siddhāntaśiromaṇi* place the *grahagaṇitādhyaṃya* as the first part of the work,²⁷ but it is the second in the *Siddhāntasundara*.²⁸

1.1.4 Manuscripts and critical editing

Photocopies of 20 manuscripts of the *Siddhāntasundara* were kindly made available to me by David Pingree for preparing this dissertation.²⁹ Some of the manuscripts contain only the *golādhyaṃya*, others only the *grahagaṇitādhyaṃya*, and yet others both the *golādhyaṃya* and the *grahagaṇitādhyaṃya*; some have leaves missing and are thus incomplete.

All the manuscripts are written in the Devanāgarī script on country-made paper.³⁰ The earliest dated manuscript was copied on Tuesday, December 25, 1663, and the most recent ones probably date from the early to middle of the 19th century.

In the manuscript tradition, when a text is copied, it undergoes changes. These are due to errors made by scribes, to corrections made to the text, and so on. As a result, different readings will occur in the different manuscripts. Depending on the text in question, its age, its popularity, and so on, these differences between the various manuscripts can be either substantial or minor.

²⁶The *Siddhāntaśiromaṇi*, in turn, is modeled in form on the *Śiṣyadhīvr̥ddhidatantra* of Lalla (see [74 . 26]).

²⁷See, e.g., [87] and [12].

²⁸Some manuscripts place the *grahagaṇitādhyaṃya* at the beginning of the *Siddhāntasundara*, an order that has become accepted in the secondary literature. However, it is clear from internal evidence that the *golādhyaṃya* commences the work. For more details, see the discussion below on p. 31.

²⁹In reality, though, there are only 18 manuscripts, as 3 of the 20 are parts of the same manuscript. Takao Hayashi also kindly provided me with copies of some manuscripts of the *bījagaṇitādhyaṃya*.

³⁰The material appears to be such from the photocopies, and this is backed up when notes on the material is given in the descriptions in manuscript catalogues.

Method of collation

In order to prepare the edition of the text of the *Siddhāntasundara*, I started by writing out the entire text, noting variant readings from 4–5 manuscripts for both the *golādhyāya* and the *grahagaṇitādhyāya*. Pingree had originally suggested that I establish a preliminary edition from just one manuscript, but this proved too difficult. With more manuscripts, it was easier to work out characters that were hard to read in one or more of them, and omissions could be spotted quickly. Of the 4–5 manuscripts that I used, I chose the first ones based on their legibility, the rest for variety. In this way, a preliminary edition was established. For the portion of the text included here, I subsequently noted the variant readings from all the available manuscripts. Overall, the preliminary edition that I established was a good one; there are only a few differences between the preliminary edition and the present edition based on all the available manuscripts.

It quickly became clear that the variations in the text between the different manuscripts are not major. Some groupings can be discerned due to occasional differences in the order of certain verses, to the inclusion of an extra verse or the omission of a verse, or to variant readings, but many of the manuscripts do not have an obvious relationship to the rest. Therefore, the attempt to establish a stemma (a tree that shows the relationship between the surviving manuscripts) has not been fully successful.³¹

Contents of this edition

In the following, references to passages in the *Siddhāntasundara* will be given as *a.b.c*, where *a* is 1 for the *golādhyāya*, 2 for the *grahagaṇitādhyāya*, and 3 for the *bījagaṇitādhyāya*; *b* is the number of the section in the chapter; and *c* is the number of the verse. For example, 2.2.8 means *grahagaṇitādhyāya*, section 2 (*spastādhikāra*), verse 8. If a reference is to a specific *pāda* of the verse, say the second, the notation 2.2.8^b will be used.

The present edition contains the following sections of the *Siddhāntasundara*:

1. the *bhuvanakośādhikāra* of the *golādhyāya*, on cosmology,
2. the *madhyamādhikāra* of the *grahagaṇitādhyāya*, on mean planetary motion,
3. the *spastādhikāra* of the *grahagaṇitādhyāya*, on true planetary motion,
4. the *tripraśnādhikāra* of the *grahagaṇitādhyāya*, on diurnal motion,
5. the *parvasambhūtyadhikāra* of the *grahagaṇitādhyāya*, on eclipse possibilities,
6. the *candragrahaṇādhikāra* of the *grahagaṇitādhyāya*, on lunar eclipses, and
7. the *sūryagrahaṇādhikāra* of the *grahagaṇitādhyāya*, on solar eclipses.

³¹See the discussion below, p. 59.

Together these sections constitute about 60% of the text.

The reason for selecting these particular chapters is that the first six chapters of the *grahagaṇitā-dhyāya* form a suitable unit of chapters dealing with mathematical astronomy, and the first chapter of the *golādhyāya* is important as it presents Jñānarāja's sources and introduces new ideas.

Principles of editing

The principle followed in the editorial process has been that the text should be intelligible and fit the context. Thus, a meaningful reading, even if only attested in very few manuscripts, is chosen over a reading that does not make sense. In a case where more than one meaningful reading is available, a choice is made either according to the grouping of the manuscripts or according to the majority reading. Jñānarāja's son Cintāmaṇi wrote a commentary on the *Siddhāntasundara*. Unfortunately, I only have parts of it available to me, but where available, I have paid close attention to how Cintāmaṇi read the verse in question.

The critical apparatus contains all variant readings, even minor spelling errors (although it has not been attempted to include all types of minor spelling errors), which makes it possible to reconstruct the text of each manuscript. Should the reader have doubts about a reading in the edition, he or she will be able to assess all the readings attested in the manuscripts.

The need for emendation has been minimal. When I have seen the need to emend the text, this is clearly indicated.

Principles of translation

Due to the technical nature of the *Siddhāntasundara*, the translation of it has been challenging. I have followed the principle that the translation should reflect the established text and be intelligible. While the *Siddhāntasundara* is composed in verse, I found that it would be near impossible to translate it into some sort of versified English; hence the translation is in English prose. I have attempted to preserve the literal sense of the Sanskrit text while giving a readable and meaningful translation.

For translating the double entendre verses mentioned above on p. 6, I can see no other way than providing two separate translations for each of them, which is what I have done.

In addition to the translation of a verse, I have provided a header for it, briefly outlining its topic. It is to be noted that these headers do not occur in the original Sanskrit text, but are editorial additions to the English translation.

1.2 Jñānarāja

1.2.1 The date of Jñānarāja and the *Siddhāntasundara*

There is no specific information in the *Siddhāntasundara* about the year it was composed, nor about when its author was born or lived. What is given in the treatise, though, are planetary positions

defining an epoch, i.e., a point in time with reference to which future computations of planetary positions are made. The point in time defined by the epochal positions is local sunrise on Friday, September 29, 1503 CE.³² While the epoch year has often been taken as the date of the composition of the *Siddhāntasundara*,³³ the two need not necessarily coincide. It is reasonable to assume, though, that the two are not too far removed from each other in time.

Also bearing on the date of Jñānarāja is a verse at the end of the *Sūryaparakāśa*, a commentary on the *Bījagaṇita* of Bhāskara II composed by Sūryadāsa, Jñānarāja's son. The first half of the verse reads:³⁴

ṣaṣṭiśakragāṇite śake kṛtaṃ
bhāṣyaṃ indugūṇavatsare nīje /

In [the year] *śaka* 1460, [this] commentary was composed, when I was in my 31st year.

According to the verse, Sūryadāsa composed the commentary in *śaka* 1460 when he was 31 years old. This means that he was born in either *śaka* 1429 or *śaka* 1430,³⁵ i.e., in 1507 CE or 1508 CE.³⁶

Finally, Jñānarāja gives a list of his ancestors at the end of the *Siddhāntasundara* (the list is given in the next section, p. 11), stating further that Rāma, the most remote ancestor mentioned, was honored by King Rāmacandra of the Yādava dynasty (r. 1271–1311 CE). Assuming a date for Jñānarāja around *śaka* 1425 and assigning 30 years to each generation, Dikshit arrives at a date of *śaka* 1215, i.e., 1293 CE or 1294 CE, for Jñānarāja's ancestor Rāma, consistent with the date of King Rāmacandra.³⁷ Although, as will be shown below, Dikshit's list of Jñānarāja's family omits one ancestor, this rough estimate remains valid. Instead of assigning 30 years to each generation, we may assume, say, 27 years per generation, and then still arrive at the time of King Rāmacandra's reign despite the extra ancestor.

Considering the epochal date, the date of Sūryadāsa's birth, and Dikshit's rough dating of Rāma, it is reasonable to date Jñānarāja and the composition of the *Siddhāntasundara* to the beginning of the 16th century CE.

³²For more details regarding the dating, see commentary on 2.1.58–64.

³³See, e.g., [65 . A.3.75] and [82 . 7.334].

³⁴Only parts of the *Sūryaparakāśa* have so far been published (see [43] and [61]), but the relevant verse is not therein. It has, however, been quoted in descriptions of the manuscripts of the *Sūryaparakāśa* given in [30 . 1.5.1010, no. 2823] and [62 . Extract 529]. In addition, Dikshit gives a paraphrase of the contents of the verse without quoting the Sanskrit (see [22 . 2.144]).

³⁵Assuming incorrectly that Sūryadāsa was 40 years old when he wrote the *Gaṇitāmṛtakūpikā* (a commentary on the *Līlāvatī* of Bhāskara II) in *śaka* 1463, Dvivedi estimates that the year of Sūryadāsa's birth was *śaka* 1423 (see [25 . 66]).

³⁶Pingree gives Sūryadāsa's year of birth as 1507 CE, see [65 . A.3.75].

³⁷See [22 . 2.141].

1.2.2 Primary source material relevant to Jñānarāja

In this section, passages from Sanskrit works containing information about Jñānarāja, his family, and so on will be given. These will be drawn on in the subsequent discussions. Some shorter passages will not be given here, but will rather be presented in due course.

In addition to a passage from Jñānarāja himself, the remainder of the passages quoted below come from the works of Jñānarāja's son Sūryadāsa, who was a prolific writer on many topics. In his works, he at times gives information pertinent to his family, and relevant extracts are presented below. Note that while there are many verses relevant to Sūryadāsa himself and his written works to be found in Sūryadāsa's works, we will limit ourselves to the verses pertinent to Jñānarāja and other ancestors of Sūryadāsa, as well as to their place of residence.

Material from Jñānarāja

At the conclusion of the *bījagaṇitādhyāya* of the *Siddhāntasundara*, Jñānarāja gives four verses that contain his genealogy as well as a bit of information about his ancestors and the place where they lived. The text of the *bījagaṇitādhyāya* has not been published, but the verses are quoted in Weber's description of a manuscript of the *bījagaṇitādhyāya*.³⁸ In addition to Weber's transcription, the four verses as rendered below are based on five manuscripts of the *bījagaṇitādhyāya*:³⁹

śrīgodottaratīrapārthivapure pūrṇākhyatīrthe pare
śrīmaddevagiriśārāmanṛpater māṇyo vadāṇyo vidām /
vidvān rāma itīha tasya tanayaḥ samprāptavidyodayo
viṣṇur nāma babhūva śāstranipunaḥ śrīnīlakaṇṭhas tataḥ //
tasmād viṣṇur abhūt prabhūtavibhavo vidyānavadyodayaḥ
sūnus tasya ca nīlakaṇṭha iva yaḥ śrīnīlakaṇṭho 'paraḥ /
tatputro 'pi tathā guṇair agaṇitaiḥ khyāto mahīmaṇḍale
svācārapratipālanaikanirataḥ śrīnāganāthābhīdhaḥ //
bhāradvājakulāvataṃsavilasadvidyo 'navadyair guṇair
yukto 'bhūd vibudho budhopama iti śrīmannṛsimhābhīdhaḥ /
tasmāt sarvakalākālāpakusālah śrīnāganātho 'bhavad
godātīrakarīndracāruvadanadhyānānuraktaḥ sadā //
sūnus tasya gaṇānānasya kṛpayā śrījñānarājaḥ sudhīr
vistīrṇād gaṇitārṇavād udaharat siddhāntasatsundaram /
ratnaṃ bhūṣaṇaḥetave 'tiguṇavac chrīmad guṇagrāhīṇāṃ
vidyāratnaparīkṣakeṣu vasatīr bhūyāt sadāsyādarāt //

³⁸The manuscript is Berlin 833 (see [104 . 231–232]).

³⁹The four manuscripts are Berlin 833 (contains all four verses), Benares 35626 (contains only the last two verses), Benares 35629 (contains only the last two verses), Scindia Oriental Research Institute 9396 (contains only the first verse), and Scindia Oriental Research Institute 9397 (contains the first, third, and fourth verses). Copies of all four manuscripts were kindly made available to me by Takao Hayashi.

In Pārthivapura, on the left bank of the Godāvarī [river], at the greatest *tīrtha*, bearing the name Pūrṇa, was a learned man, Rāma by name, who was honored by King Rāma, the ruler of Devagiri, and who was eloquent among the learned. His son, whose rising of knowledge had been attained, was called Viṣṇu. From him [came forth a son called] Nīlakaṇṭha, who was skilled in the *śāstras*.

From him came forth [a son called] Viṣṇu, whose power was great and in whom there was a faultless [sun]rise of knowledge. He had a son [called] Nīlakaṇṭha, who like [the deity] Nīlakaṇṭha [i.e., Śiva], was unrivaled. His son, bearing the name Nāganātha, was celebrated on the Earth due to his innumerable good qualities, and he was guarding his own [religious] practice, which he was single-mindedly engaging in.

[His son,] who bore the name Nṛsiṃha, whose learning was playful, and who descended in the Bhāradvāja family, was endowed with faultless good qualities and very learned, like a sage, it is said. From him [came forth a son called] Nāganātha, who was expert in the whole collection of arts, and who was always fond of meditating on the smiling face of [the deity] Gaṇeśa [while sitting] on the bank of the Godāvarī river.

His son, by the mercy of [the deity] Gaṇeśa, was the intelligent Jñānarāja, who extracted the jewel [called] the *Siddhāntasatsundara* from the wide ocean of computation, [a jewel that] has many qualities and that is lustrous, for the sake of adorning those who appreciate good qualities. May its abode always respectfully be among the examiners of the jewels of knowledge.

Material from the *Sūryaprakāśa* of Sūryadāsa

The *Sūryaprakāśa* is a commentary on the *Bījagaṇita*, a work on algebra, of Bhāskara II. No complete edition is available, but parts of the *Sūryaprakāśa* have been edited and published.⁴⁰

The following three verses from the end of the *Sūryaprakāśa* are not included in any of the two partial editions that have been published, but they have been quoted in descriptions of manuscripts of the *Sūryaprakāśa*:⁴¹

*gododaktaṭapūrṇatīrthanikaṭāvāse tathā maṅgalā-
gaṅgāsaṅgamatas tu paścimadiśi krośāntareṇa sthite /
śrīmatpārthapure babhūva paramācāro dvījanmāgraṇīr
jyotiḥśāstravicāravistṛtamatiḥ śrīnāganāthābhīdhaḥ //*

*putras tasya kalākalāpakusālaḥ kṣmāpālamālārcitaḥ
saujanyaikasudhākaraḥ kṣititale saubhāgyabhāgyāspadam /
kīrtir yasya digantareṣu vibudhair vyākhyātaśāstrāgamair
vikhyāto nanu satkavir vijayate śrījñānarājābhīdhaḥ //*

⁴⁰See [43] and [61].

⁴¹See [30 . 5.1010, entry 2823] and [62 . Extract 529].

*siddhāntaṃ suṇḍarākhyāṃ grahaṇitavidhau jātaka caikam
 ekaṃ sāhitye gītaśāstre param idam akarod yaś caturgrantharatnam /
 tatsūnuḥ sūryadāsaḥ sujanavidhividāṇaṃ prītaye bīja-
 bhāṣyaṃ cakre sūryaparakāśaṃ svamatiparicayād āditaḥ sopapattiṃ //*

In Pārthapura, which is located a *krośa* [a measure of distance is about $2\frac{1}{4}$ miles, or a bit more than $3\frac{1}{2}$ kilometers] west of the confluence of the Maṅgalā and the Gaṅgā⁴² [rivers] in the vicinity of Pūrṇatīrtha on the left bank of the Godāvarī river, there was a man bearing the name Nāganātha, who had the highest conduct, who was a leader of the *brāhmaṇas*, and whose extensive intelligence [was engaged in] a reflection on *jyotiḥśāstra* [i.e., the astral sciences].

His son, who was skilled in all of the arts, who was honored by a succession of kings and who was the one Moon of friendliness, was the abode of happiness and prosperity on Earth. He, the good poet bearing the name Jñānarāja, conquers, whose fame is indeed celebrated in other lands by the wise who have written commentaries on the *śāstras* and *āgamas*,

and who wrote four works, a *siddhānta* entitled Sundara on the rule of planetary computation, one on horoscopy, one on rhetoric, and another on the art of singing. His son, Sūryadāsa, wrote the *Sūryaparakāśa*, a commentary on the *Bījagaṇita* [of Bhāskara II] along with demonstrations, beginning from an accumulation of his own understanding for the pleasure of those who know the rules of good people.

Material from the *Prabodhasudhākara* of Sūryadāsa

The *Prabodhasudhākara* is a work on *vedānta*, one of the philosophical systems of India, that has not been published. A relevant verse from the text has been quoted from a manuscript by Sarma:⁴³

*godāyās tīrabhāge hariharanīlaye pūrṇatīrthopakaṇṭhe
 grāme yaḥ prastarākhye gaṇakagaṇagaṇagrāmaṇīr jñānarājah /
 tatsūnuḥ sarvavidyānidhir adhikalākāvyaḥ bhāṣābhīdhāyī
 provācādhyātmahārdaṃ tadanubhavavatāṇaṃ prītaye sūryasūriḥ //*

Jñānarāja, the chief of the body of people possessing the qualities of a mathematician, [lived] in a village called Prastara in the vicinity of Pūrṇatīrtha, the dwelling place of [the deities] Viṣṇu and Śiva, on the bank of the Godāvarī [river]. His son Sūryadāsa, who is an ocean of all knowledge, spoke the essence of that which relates to the Self expressed in the language of the arts and poetry for the satisfaction of those who have a feeling for that.

⁴²Here the word “Gaṅgā”, which usually means the river Ganges in North India, refers to the Godāvarī river, the Ganges of the Deccan.

⁴³See [85 . 224].

Material from the *Gaṇitāmṛtakūpikā* of Sūryadāsa

The *Gaṇitāmṛtakūpikā* is a commentary on the *Līlāvatī* of Bhāskara II. It has not been published, but the following verses from the end of the work are quoted in a manuscript catalogue:⁴⁴

asti trastasamastadoṣanicayaṃ godāvidarbhāyuteḥ
krośenottarataḥ taduttarataḥ pārthābhīdhānaṃ puram /
tatrābhūd gaṇakottamaḥ pṛthuyasāḥ śrīnāganāthābhīdhō
bhāradvājakule sadaiva paramācāro dvījanmāgraṇīḥ // 1 //

putras tasya kalākalāpakusālaḥ kṣmāpālamālārcitaḥ
saujanyaikasudhākaraḥ kṣītitale saubhāgabhāgyāspadaṃ /
kīrtir yasya digantareṣu vividhair vyā[khyā]nasaṅkhyāgamair
vikhyātā nanu satkavir vijayate śrījñānarājābhīdhāḥ // 2 //

There is a city called Pārthapura, on account of which the entire multitude of faults tremble, one *krośa* north of the confluence of the Godāvarī and Vidarbhā rivers, on the northern bank of it [the confluence]. There [in Pārthapura] was a man called Nāganātha, the best among mathematicians and of wide renown, who belonged to the Bhāradvāja family, who was always of the highest conduct, and who was a leader of the *brāhmaṇas*.

His son, who was skilled in all of the arts, who was honored by a succession of kings and who was the one Moon of friendliness, was the abode of happiness and prosperity on Earth. He, the good poet bearing the name Jñānarāja, conquers, whose fame is indeed celebrated in other lands by various texts of mathematics with commentaries.

Material from the *Nṛsiṃhacampū* of Sūryadāsa

The *Nṛsiṃhacampū* is a *campū* (a poetical work written in mixed verse and prose) narrating the story of Nṛsiṃha, one of the incarnations of the deity Viṣṇu. It has been published.⁴⁵ At the end of the work, the first of the two verses from the end of the *Gaṇitāmṛtakūpikā* (possibly with minor variations) is given. This verse as given in the printed edition contains many errors, but it has been reproduced better in an entry in a manuscript catalogue.⁴⁶

Material from the *Paramārthaprapā* of Sūryadāsa

The *Paramārthaprapā* is a commentary on the *Bhagavadgītā*, a very important religious text in Hinduism. At the conclusion of the *Paramārthaprapā*, Sūryadāsa gives the following verse:⁴⁷

⁴⁴Cited in [30 . 5.1005, entry 2809].

⁴⁵See [88].

⁴⁶See [88 . 79], where, for example, Pārthapura is given as Vāryapura, and Jñānarāja's name is given as Jānarāta. For the better transcription, see [30 . 7.1548, entry 4051].

⁴⁷See [49 . 3.1327].

*gododaktaṭapūrṇatīrthanikaṭe pārthābhīdhānaṃ puraṃ
tatra jyotiṣikānvaye samabhavac chrījñānarājābhīdhah /*

There is a city called Pārthapura in the vicinity of Pūrṇatīrtha on the left bank of the Godāvarī [river]. In that [city], in a family of astronomers, [a man] bearing the name Jñānarāja was born.

1.2.3 Jñānarāja's family background

As has been stated clearly in passages quoted above by both Jñānarāja and Sūryadāsa, Jñānarāja was descended from a *brāhmaṇa* family tracing its descent to the sage Bhāradvāja living in a city called Pārthapura, about 300 miles from Devagiri, the capital of the Yādava dynasty. From the descriptions given, the family was learned and traced its lineage back to an ancestor who was honored by one of the Yādava kings.

Jñānarāja's genealogy

A passage of four verses coming at the end of the *bījagaṇitādhyāya* in which Jñānarāja presents his genealogy was given above. Based on Weber's transcription of the passage, the genealogy is given by Aufrecht in the *Catalogus Catalogorum*.⁴⁸ An expanded genealogy based on Aufrecht and communications he had at the end of the 19th century with a descendant of Jñānarāja, called Kāśīnātha Śāstrī, is given by Dikshit.⁴⁹ Dikshit notes that in the genealogical table sent to him by Kāśīnātha Śāstrī, the name of Nṛsiṃha's father is given as Daivajñarāja,⁵⁰ whose name begins that table. Dikshit suggests, reasonably, that presumably Nāganātha or an earlier ancestor received the title *daivajñarāja* (literally, king among those who knows the destinies of men (astrologers)). Based on the information gathered from Kāśīnātha Śāstrī, Dikshit was able to list descendants of Jñānarāja in addition to ancestors,⁵¹ but the list of ancestors given by him does not differ from those given by Aufrecht. Finally, Pingree gives expanded genealogies based on Dikshit's account.⁵²

It is to be noted that the genealogies given by these scholars contain omissions from Jñānarāja's verses. Rather than reflecting different sources, these omissions appear to be mere errors: Aufrecht's genealogy is based on Weber (who, as noted above, quotes Jñānarāja's four verses in their entirety), Dikshit's genealogy is based on Aufrecht and Kāśīnātha Śāstrī, and Pingree's sources are Aufrecht and Dikshit.⁵³

⁴⁸See [2 . 1.505, under the entry "Rāma of Pārthapura"].

⁴⁹See [22 . 2.140].

⁵⁰The name is given as Daivajñarāja later in the same paragraph.

⁵¹Dikshit gives some brief information about Jñānarāja's descendants, including Kāśīnātha Śāstrī, in [22 . 140, 142].

⁵²See [65 . A.3.75] and [74 . 124, table 9]. See also [74 . 120].

⁵³It may also be noted that Peterson gives a very deficient genealogy based on Aufrecht in [62 . 80, entry 1870], listing only Rāma, Viṣṇu, Nīlakaṇṭha, Nāganātha, Jñānarāja, and Jñānarāja's son Sūryadāsa.

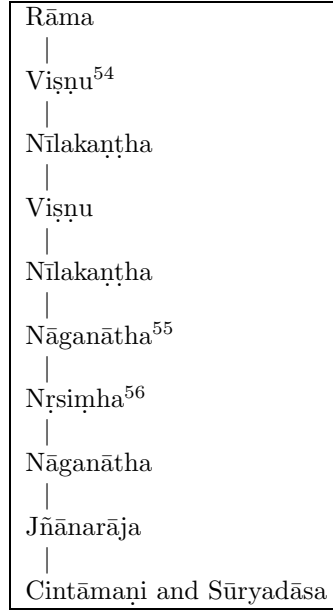


Table 1.1: Jñānarāja’s genealogy as given in the *Siddhāntasundara*

A table of Jñānarāja’s genealogy based on the four verses, with Jñānarāja and his two sons added at its bottom, is given in Table 1.1.

Jñānarāja’s ancestor Rāma

According to Jñānarāja, Rāma, the most distant ancestor mentioned, was honored by King Rāma, the ruler of Devagiri. Gaṇeśa, a member of Jñānarāja’s family who composed two works on astrology, likewise connects his ancestry with King Rāma of Devagiri.⁵⁷ Aufrecht and Pingree identify this King Rāma as King Rāmacandra of the Yādava dynasty, who reigned 1271–1311 CE.⁵⁸

Dikshit, referring to Aufrecht, states that Rāma flourished at the court of King Rāmacandra,⁵⁹ and Minkowski writes that an ancestor of Jñānarāja (who must be Rāma) served at the court of the

⁵⁴Omitted by Aufrecht, Dikshit, and Pingree.

⁵⁵Omitted by Pingree in [74].

⁵⁶Omitted by Pingree in [74].

⁵⁷Gaṇeśa flourished in the second half of the 16th century CE (see [65 . A.2.107–110, A.3.28, A.4.75–76, A.5.74–75], especially [65 . A.3.28] for Gaṇeśa’s date). The verses in which Gaṇeśa gives information about himself and his family are the two last verses of the *Tājikabhūṣaṇa* and *Ratnāvalīpaddhati* 8.12–14, all of which are quoted in [65 . A.2.109].

⁵⁸See [2 . 1.505, entry “Rāma of Pārthapura”] and [74 . 120, fn. 6]. Note that there is only one king named Rāma or Rāmacandra in the genealogy of the Yādavas of Devagiri given in [103 . 368].

⁵⁹See [22 . 2.140]. Aufrecht, however, only says “Rāma of Pārthapura (under Rāma, king of Devagiri), father of ...” (see [2 . 1.505]).

Devagiri Yādavas as a *śāstrin*, or learned scholar.⁶⁰ However, Jñānarāja places Rāma in Pārthivapura, not in Devagiri, the Yādava capital, and does not give more details than that Rāma was honored by King Rāma. The nature of the honor conferred on Rāma by the king is not known, nor are the services that he performed in order to earn it.

Other ancestors

Other than their names and that they are praised as learned men, we know hardly anything about the ancestors between Rāma and Jñānarāja's father Nāganātha. No works composed by any of them are listed by Pingree.⁶¹

Nāganātha, Jñānarāja's father

Jñānarāja describes his father Nāganātha as a learned man who was fond of meditating on the smiling face of the deity Gaṇeśa at the bank of the Godāvarī river. Sūryadāsa, in the second verse quoted from the end of the *Sūryaparakāśa* and the first verse quoted from the *Gaṇitāmṛtakūpikā*, describes Nāganātha as accomplished in *jyotiḥśāstra* (the astral sciences) and in computation.

The *New Catalogus Catalogorum* lists Nāganātha as the probable author of a work entitled *Parvaprabodha*.⁶² This attribution is, however, not given by Pingree in his *Census of the Exact Sciences in Sanskrit*, where, instead, a *Parvaprabodha* is given as the work of a later scholar, Nāgeśa, who composed it in 1628 CE.⁶³ This is likely the same text, which is thus not a work of Jñānarāja's father. Note that the meaning of the Sanskrit names Nāganātha and Nāgeśa is the same.

Nāganātha is sometimes called by slightly different names in manuscript catalogues: for example, Nāgarāja,⁶⁴ or Nāga.⁶⁵ In one manuscript colophon, he is furthermore called Raṅganātha.⁶⁶ These variations are due to minor errors in some colophons or concluding verses of chapters in manuscripts of the *Siddhāntasundara*.

Jñānarāja's wife

In the *Sūryodayakāvya*, a poetical work written in praise of Jñānarāja's son Sūryadāsa,⁶⁷ the name of Jñānarāja's wife is given as Ambikā.⁶⁸

⁶⁰See [51 . 502] and [52 . 354].

⁶¹See [74 . 124, Table 9].

⁶²See [82 . 10.4].

⁶³See [65 . A.5.167].

⁶⁴See [58 . 351, no. 1241].

⁶⁵See [4 . 187, no. 452] and [55 . 85–86, no. 1767].

⁶⁶See f. 71r in V₂.

⁶⁷See [50].

⁶⁸*Sūryodayakāvya* 1.18. The edition used is [50].

Jñānarāja's sons

Jñānarāja had (at least) two sons, Cintāmaṇi and Sūryadāsa,⁶⁹ who were both learned men and well versed in astronomy. Cintāmaṇi is sometimes stated to have been the younger brother of Sūryadāsa,⁷⁰ but I have not seen any sources that corroborate this. Pingree states that Cintāmaṇi flourished in about 1530 CE and that Sūryadāsa lived 1507–88 CE.⁷¹

Cintāmaṇi

The only known work of Cintāmaṇi is a voluminous commentary on his father's *Siddhāntasundara* entitled *Grahagaṇitacintāmaṇi*.⁷² In the *Grahagaṇitacintāmaṇi*, Cintāmaṇi elaborates on and defends his father's position on the *virodhāparihāra* issue. He further writes amply on the properties of objects, and he describes physical experiments. Most important, however, is his attempt at integrating *jyotiḥśāstra* (the astral sciences), traditionally on the periphery of the *śāstras*, or the “knowledge systems” of India, with the other *śāstras*. In particular, he recasts Jñānarāja's arguments and demonstrations in the language of the philosophical *śāstras*.⁷³

Sūryadāsa

Also known as Sūrya Paṇḍita, Sūryadeva, Sūrya Kavi, Sūrya Gaṇaka, Sūrya Sūri, Daivajña Paṇḍita Sūrya, Daivajña Sūrya Paṇḍita, Ācārya Sūrya, or simply Sūrya,⁷⁴ Sūryadāsa was a polymath and a prolific writer on many subjects. He is the most widely known member of Jñānarāja's family. His works include commentaries on the works of Bhāskara II, poetic works, a commentary on religious works such as the *Bhagavadgītā* and the *vedas* (a group of ancient texts sacred to Hinduism), works on astronomy, and more.⁷⁵ Minkowski credits him with the invention of a genre of poetry called *vilomakāvya*, in which each verse can be read both from left to right and from right to left, giving two different narratives.⁷⁶ So famed was Sūryadāsa's learning that a poetical work entitled *Sūryodaya-kāvya* was written about his life and deeds.⁷⁷

⁶⁹For information about Cintāmaṇi, see [65 . A.3.49, A.4.94], [51 . 504–507], and [52 . 360–364]. For information about Sūryadāsa, see [22 . 2.144–145], [51 . 507–508], [52 . 364–367], and [53 . 329–330].

⁷⁰See [102 . 1.4.94–95, entry 291] and [82 . 7.58].

⁷¹See [65 . A.3.49, A.3.75].

⁷²See [65 . A.3.49, A.4.94], [74 . 30], and [52 . 360]. Two manuscripts, M₃ and V₁, used for the edition of the *Siddhāntasundara* contain the *Grahagaṇitacintāmaṇi*; both manuscripts are, however, incomplete.

⁷³See [51 . 504–506] and [52 . 361–362].

⁷⁴See [43 . 1].

⁷⁵Regarding the works of Sūryadāsa, see [85 . 222–224]. A more recent investigation of Sūryadāsa's written works is [35].

⁷⁶See [53].

⁷⁷See [50]. No thorough study of this text has been undertaken here, but such a study would presumably add much valuable information to what we know about Sūryadāsa and Pārthapura. I am thankful to Neal Delmonico for drawing my attention to this text.

1.2.4 Native place of Jñānarāja's family

The place where Jñānarāja's family lived has been identified by Jñānarāja and Sūryadāsa both by name and by proximity to other locations. The family later relocated to Bid, a nearby town.⁷⁸

Pārthapura

According to the first of the four verses quoted from the *bījagaṇitādhyāya* above, Jñānarāja's family (or at least Rāma, the first ancestor mentioned) resided in a city (*pura*) called Pārthivapura.

In the verses quoted from the works of Sūryadāsa, Nāganātha, Jñānarāja's father, is said to have lived in Pārthapura. Presumably it is understood that Jñānarāja did as well. However, in the verse quoted from the *Prabodhasudhākara*, Sūryadāsa says that Jñānarāja lived in a village (*grāma*) called Prastara. Goodwin is probably correct when he suggests that this is the village outside Pārthapura where Jñānarāja lived.⁷⁹

Regarding other sources, Jñānarāja's city is called Pārthavālapura in the *Sūryodayakāvya*,⁸⁰ Pātharī by the astronomer Kamalākara (fl. about 1658 CE),⁸¹ and Pāthrī in Islamic sources.

Pūrṇatīrtha

Both Jñānarāja and Sūryadāsa make reference to a *tīrtha* (ford or place of pilgrimage) called Pūrṇatīrtha, which is in the proximity of Pārthapura. In a list of *tīrthas*, Kane notes that Pūrṇatīrtha is mentioned in the *Brahmapurāṇa*.⁸² The *Brahmapurāṇa*, a sacred Hindu text, contains a long section, the *Gautamīmāhātmya*, that praises sacred places and locations along the Godāvarī river. In that section, a chapter is devoted to praising the glories of Pūrṇatīrtha and other sacred places.⁸³ According to the *Brahmapurāṇa*, Pūrṇatīrtha is on the left (northern) bank of the Godāvarī, is the dwelling place of the deities Viṣṇu and Śiva, and is at the confluence of the Maṅgalā and the Godāvarī rivers.⁸⁴

The location of Pārthapura

About the location of Pārthapura we are told the following by Jñānarāja and Sūryadāsa:

1. Jñānarāja states that Pārthivapura is on the left (northern) bank of the Godāvarī river at Pūrṇatīrtha (see p. 11).

⁷⁸ [22 . 2.143]. According to the *Sūryodayakāvya*, Sūryadāsa went to Bid, so probably it was with him that the family (or part of it) moved there (see [50 . iii]).

⁷⁹ See [35 . 36].

⁸⁰ *Sūryodayakāvya* 1.15.

⁸¹ See [22 . 2.151–152]. For Kamalākara, see [65 . A.2.21–23, A.3.18, A.4.33, A.5.22].

⁸² See [45 . 4.793].

⁸³ *Brahmapurāṇa* 122 (*Gautamīmāhātmya* 53). The edition used is [90].

⁸⁴ *Brahmapurāṇa* 122.1–2 and 122.100 (*Gautamīmāhātmya* 53.1–2 and 53.100).

2. In the first of the verses quoted above from the end of Sūryadāsa's *Sūryaparakāśa* (see p. 12), it is stated that Pārthapura is located at a distance of one *krośa* (about $2\frac{1}{4}$ miles, or a bit more than $3\frac{1}{2}$ kilometers) to the west of the confluence of the Maṅgalā and the Godāvarī on the left (northern) bank of the Godāvarī⁸⁵ near Pūrṇatīrtha.⁸⁶
3. In the first of the verses quoted above from the end of Sūryadāsa's *Gaṇitāmṛtakūpikā* (see p. 14), Pārthapura is located on the left (northern) bank of the Godāvarī at a distance of one *krośa* north of the confluence of the Godāvarī and the Vidarbhā.
4. In the verse quoted from the *Prabodhasudhākara* (see p. 13), Sūryadāsa says that the village Prastara, where he says that Jñānarāja lived, is near Pūrṇatīrtha on the bank of the Godāvarī.

There has been some confusion about the rivers mentioned by Sūryadāsa. Dikshit believes that the Vidarbhā is the same river as the Maṅgalā,⁸⁷ and in the *Catalogue of the Sanskrit Manuscripts in the Library of the India Office*, the Maṅgalāgaṅgā mentioned by Sūryadāsa at the end of the *Sūryaparakāśa* is taken as one river and identified with the Vidarbhā.⁸⁸ However, the word *maṅgalā-gaṅgā* is not to be read as indicating just one river, but rather as indicating two, as Gaṅgā here refers to the Godāvarī river. Furthermore, the *Brahmapurāṇa* clearly considers the Vidarbhā and the Maṅgalā to be two separate rivers. Whereas the Maṅgalā river is mentioned in connection with Pūrṇatīrtha, the confluence of the Vidarbhā and the Godāvarī is praised in a separate chapter.⁸⁹ It is clear, though, that the two rivers are not far from each other.

Identification of Pārthapura

From the discussion of the location of Pārthapura above, it is clear that Pārthivapura, Pārthapura, and Pārthavālapura must be different names of the same city. It is not clear, however, why the city is referred to by all of these three names. According to Kher, Pārthapura is named after Arjuna, one of the protagonists of the *Mahābhārata*, a well-known Sanskrit epic.⁹⁰ Arjuna is known by the matronymic Pārtha (after his mother Pṛthā), but he is not called Pārthiva, a word that generally means “king” in Sanskrit. Both of the words *pārtha* and *pārthiva* are ultimately derived from the Sanskrit etymological root *pṛth*, “to extend, to be broad”, which could possibly be a clue to the meaning of the name of the city.

⁸⁵The Godāvarī river is considered to have the same source as the river Ganges in North India (see [42 . 299]). Hence texts from the region of this river often call it Gaṅgā, the Sanskrit name for the Ganges. Thus the Gaṅgā in the verses quoted from Sūryadāsa does not refer to the Ganges in North India, but to the Godāvarī river in the Deccan.

⁸⁶For Pūrṇatīrtha, see below.

⁸⁷See [22 . 2.141].

⁸⁸See [30 . 5.1004, entry 2809] and [30 . 5.1010, entry 2823]. Goodwin similarly takes Maṅgalāgaṅgā as referring to the Vidarbhā (see [35 . 36]).

⁸⁹*Brahmapurāṇa* 121 (*Gautamīmāhātmya* 52).

⁹⁰See [46 . 6]. Kher gives the second edition of Dikshit's *Bharatiya Jyotish Shastracha Itihas* (in Marathi) published in Pune in 1931 as the source of this claim. I have not been able to consult this work, but there is no mention in the English translation of Dikshit's work (see [22]) of Pārthapura being named after Arjuna.

Dikshit identifies Pārthapura as the modern Pathri, which Pingree places in the Parbhani District of Maharashtra.⁹¹ Lalye similarly identifies Pārthavālapura with Pathri.⁹² This identification seems certain.

History of Pārthapura

Pārthapura is not only the ancestral home of Jñānarāja's family, it is also the ancestral home of the Muslim Nizām Shāhī dynasty that ruled the Ahmadnagar kingdom. As Islamic sources refer to Pārthapura as Pāthri, we will use that name in the following historical account.

According to the Muslim historian Firishta (fl. about 1560–1620 CE), Ahmad Nizām Shāh (r. 1490–1509),⁹³ the founder of the Nizām Shāhī dynasty, was the son of a *brāhmaṇa* named Tīma (or Timapa), who received the name Malik Hasan Bahrī when he converted to Islam. He was the son of Bhairava, a Kulkarni (a hereditary village accountant) *brāhmaṇa* from Pāthri.⁹⁴

Ahmad Nizām Shāh was succeeded by his son Burhān Nizām Shāh (r. 1509–1553),⁹⁵ who was approached by his relatives in Pāthri who "... wished to enjoy the protection and patronage of their royal kinsman."⁹⁶ At that time, Pāthri was on the frontier between the Islamic kingdoms of Ahmadnagar and Berar, but belonged to the latter. In keeping with his relatives' desire, Burhān Nizām Shāh offered 'Alā-ud-dīn 'Imād Shāh, the king of Berar, a favorable exchange for the town of Pāthri. The request was denied, however, and 'Alā-ud-dīn 'Imād Shāh began fortifying the town. Burhān Nizām Shāh subsequently, in 1518, invaded and conquered Pāthri, which he held until 1527, when 'Alā-ud-dīn 'Imād Shāh retook the city.⁹⁷ The army of Berar was, however, unable to hold it, and in that same year it fell again to Burhān Nizām Shāh. Firishta writes that Burhān Nizām Shāh destroyed the fort of Pāthri after a siege lasting two months, and proceeded to give the district in charity to his *brāhmaṇa* relations there, who kept it until the time of Emperor Akbar.⁹⁸ 'Alā-ud-dīn 'Imād Shāh appealed for help to the king of Gujarat,⁹⁹ whose intervention forced Burhān Nizām Shāh to agree to a peace agreement, according to which he was, among other things, to return Pāthri to Berar. This, however, never happened.¹⁰⁰

In 1596, the Mughal army led by 'Abd al-Raḥīm, who had been awarded the title Khān-i Khānān,

⁹¹For Dikshit's identification, see [22 . 2.141]. For Pingree, see [74 . 120].

⁹²See [50 . iii].

⁹³See [38 . 704].

⁹⁴See [32 . 3.116, 130], [38 . 398], and [5 . 108]. For the Kulkarni title, see [32 . 3.130, fn. 93].

⁹⁵See [38 . 704].

⁹⁶See [38 . 435]. According to Firishta, they desired to have their ancestral rights (i.e., the position as Kulkarni) restored (see [32 . 3.130]).

⁹⁷See [38 . 435].

⁹⁸See [32 . 132].

⁹⁹See [38 . 324].

¹⁰⁰See [38 . 325, 436].

defeated the army of Ahmadnagar at Pāthri.¹⁰¹

These events took place after the composition of the *Siddhāntasundara*, but during the times when Jñānarāja's sons, Cintāmaṇi and Sūryadāsa, were writing their works. The events further illustrate the situation in the area at the time: general unrest between rivaling Islamic kingdoms.

1.3 The *Siddhāntasundara*

1.3.1 Indian astronomy

Before proceeding to a discussion of the *Siddhāntasundara* and its contents, a brief overview of Indian astronomy will be helpful.

The Indian astronomical system seeks to describe planetary motion, compute lunar and solar eclipses, and so on. The model employed is geocentric, and uses epicycles to describe the motion of the planets (in accordance with ancient terminology, here and in the following the word “planet” will denote either one of the two luminaries, i.e., the Sun and the Moon, or one of the five planets known to the ancient Indians, i.e., Venus, Mercury, Mars, Jupiter, and Saturn; if it necessary to distinguish further, the former are called luminaries and the latter star-planets). An epicycle is a circle that moves around the Earth with its center always at the same distance from the Earth's center. In the case of the two luminaries, the planet moves on the epicycle, whereas in the case of the star-planets, two epicycles are used to describe the planet's motion (one accounting for the fact that the planet orbits the Sun, not the Earth, and the second for the fact that the orbit is not circular but elliptical). The model is a pre-Ptolemaic Hellenistic model following certain Aristotelian principles that was transmitted to India in the first half of the first millennium CE, but also contains certain distinct Indian features, such as supernatural beings causing the motion of the planets using cords of wind.

Unlike ancient Greek astronomy, Indian astronomy operates with a sidereal zodiac. This means that the position of the Sun and the other planets is measured with respect to the fixed stars, not, as in the tropical zodiac of Greek astronomy, with respect to the vernal equinox.

The Indian astronomical system operates with lunar months, i.e., a month is the period from one conjunction of the Sun and the Moon to the next. During such a lunar month, the Moon moves further from the Sun until catching up with it. When the Moon has moved 12° away from the Sun, a time period known as a *tithi* has passed. When the Moon has moved another 12° away from the Sun (i.e., when the angular distance between the two luminaries is 24°) another *tithi* has passed, and so on. There are thus 30 *tithis* in a lunar month. A civil day, i.e., the period from one sunrise to the next, or from one midnight to the next (depending on which school of Indian astronomy one follows) is divided into 60 *ghaṭikās*. Each *ghaṭikā*, in turn, is divided in 60 *palas*.

¹⁰¹See [77 . 84]. For the life of the Khān-i Khānān, see [57].

Classical schools of Indian astronomy

Indian astronomical texts are generally divided according to a number of *pakṣas*, or schools. The different *pakṣas* differ in certain details, such as some astronomical parameters. For example, a day begins at sunrise in the *brāhmapakṣa*, but at midnight in the *ārdharātrikapakṣa* and the *saurapakṣa*.

The *brāhmapakṣa*,¹⁰² the oldest of the *pakṣas*, is believed to be a revelation of the deity Brahman, and its founding text is a treatise entitled the *Paitāmahasiddhānta*,¹⁰³ which survives only in corrupted form in a larger compilation, the *Viṣṇudharmottarapurāṇa*. Important *brāhmapakṣa* texts include Brahmagupta's *Brāhmasphuṭasiddhānta*¹⁰⁴ and Bhāskara II's *Siddhāntaśiromaṇi*.

The *āryapakṣa*¹⁰⁵ was founded by Āryabhaṭa, one of the most famous astronomers in Indian history, and its main text is his *Āryabhaṭīya*.¹⁰⁶ Like the *brāhmapakṣa*, Āryabhaṭa credits Brahman with a revelation of astronomy.

The *ārdharātrikapakṣa*¹⁰⁷ is like the *āryapakṣa* founded by Āryabhaṭa, but its founding text is now lost. The name of the school is derived from its use of a midnight (*ardharātra*) epoch.

The *saurapakṣa*¹⁰⁸ is based on a *Sūryasiddhānta* from the late 8th or early ninth century CE. Jñānarāja's *Siddhāntasundara* belongs to the *saurapakṣa*.

The cosmology of the *purāṇas*

The *purāṇas* are a class of sacred texts in Hinduism. Their content is encyclopedic, encompassing mythology, religion, divination, cosmology, ancient legends, and much more. Due to the sacred nature of these works, and the subsequent acceptance of their cosmology in the larger Hindu world, it is necessary briefly to outline their cosmology (according to Pingree, the source of cosmological material in the *purāṇas* probably dates from the early centuries CE¹⁰⁹). Many of the concepts of the cosmology of the *purāṇas* were incorporated into the cosmological model of the astronomers.

According to the *purāṇas*, the Earth is a flat disc at the center of which is a huge mountain, Meru. A circular region called Jambūdvīpa surrounds Meru, and at the southern part of Jambūdvīpa is Bhāratavarṣa, that is, India. Jambūdvīpa is surrounded by an annular ocean of salt water, and this ocean is, in turn, surrounded by alternating annular regions and oceans. There are seven annular oceans in total.

The planets revolve above the Earth around an axis through Meru, with the Sun closer to the Earth than the Moon. When the Sun is behind Meru, it is night, when it is in front, it is day.

¹⁰²For the *brāhmapakṣa*, see [71 . 555–589].

¹⁰³See [65 . A.4.259–260].

¹⁰⁴For Brahmagupta and the *Brāhmasphuṭasiddhānta*, see [65 . A.4.254–257, A.5.239–240].

¹⁰⁵For the *āryapakṣa*, see [71 . 590–602].

¹⁰⁶For Āryabhaṭa, see [64], [65 . A.1.50–53, A.2.15, A.3.16, A.4.27–28, A.5.16–17] and [79].

¹⁰⁷For the *ārdharātrikapakṣa*, see [71 . 602–608].

¹⁰⁸For the *saurapakṣa*, see [71 . 608–618].

¹⁰⁹See [71 . 554–555].

As is clear, the cosmology of the *purāṇas* is inconsistent with the cosmology of the astronomical tradition. The traditional approach to this on the part of the astronomers was to incorporate certain elements of the cosmology of the *purāṇas* into their model while rejecting others. As we shall see below in the section “The issue of *virodhaparihāra*” on p. 49, Jñānarāja’s approach was to seek a synthesis without rejecting outright elements from the tradition of the *purāṇas*.

Types of astronomical treatises

A number of different types of astronomical treatises were composed in India.

The most extensive of them are called *siddhāntas*. A *siddhānta* generally contains theory as well as mathematical algorithms and formulae. A *siddhānta* bases its computations on the beginning of creation, that is the beginning of the *kalpa* (a *kalpa* is a period of 4,320,000,000 years during which the universe exists; for the world ages, see 2.1.2–3).

Comparable to a *siddhānta*, a *tantra* also contains theory, but bases its computations on the beginning of the current *kaliyuga* (the last age in a *kalpa*, spanning 432,000 years). The line between a *siddhānta* and a *tantra* is not always clearly defined. For example, Jñānarāja refers to his *Siddhānta-sundara*, a *siddhānta*, as a *tantra* numerous times.¹¹⁰

A *karāṇa* is a smaller astronomical work. It does not contain theory the way that a *siddhānta* does, and its formulae are geared towards ease of practical application. The computations are based on an epoch close in time to the date of the composition of the *karāṇa*.

A *koṣṭhaka* is an astronomical table meant to facilitate astronomical computations for casters of horoscopes and makers of calendars.¹¹¹

Representation of numbers in Indian mathematics and astronomy

Expressing numbers is unavoidable in an astronomical treatise. In Sanskrit astronomical and mathematical texts, numbers are generally expressed using a system known as *bhūṭasaṅkhyā* (literally, object-numeral).¹¹² The *bhūṭasaṅkhyā* system assigns a numerical value to certain Sanskrit words. For example, the Sanskrit word *danta* (tooth) represents the number 32, the Sanskrit word *sāgara* (ocean) represents the number 4 (after the four oceans in the Indian tradition), and the Sanskrit word *śara* (arrow) represents the number 5 (after the five arrows of Kāmadeva, the Indian god of love).¹¹³ Larger numbers can be created by combining two or more such words in a compound, which is read numerically from right to left. Using hyphens to separate the members of each compound for the sake of clarity, we have that *śara-danta* means 325, *danta-sāgara-śara-śara-śara* means 555432, and *danta-śara-danta-danta-sāgara-śara* means 543232532.

¹¹⁰See, e.g., 1.1.79.

¹¹¹See [71 . 41].

¹¹²See [86 . 38–41].

¹¹³For a list of Sanskrit words corresponding to a given number, as well as a list of Sanskrit words and their corresponding number, see [86 . 59–69].

Integral numbers are expressed using the same decimal system that we use today. As such, 47326 is written simply as ४७३२६, and 51908 as ५१९०८. Fractional parts of numbers, however, are not expressed using the decimal system, but rather by using sexagesimals. In other words, in the Indian tradition, a number a is represented as

$$a = n + \frac{m_1}{60} + \frac{m_2}{60^2} + \dots + \frac{m_k}{60^k}, \quad (1.1)$$

where $n, m_1, m_2, \dots, m_k$ are integers, and $0 \leq m_i < 60$ for $i = 1, 2, \dots, k$. To give an example, the number $82\frac{23}{50} = 82.46$ is represented as $82 + \frac{27}{60} + \frac{36}{60^2}$. In Sanskrit texts, the integral part of a number and its sexagesimal parts are usually separated by the symbol ।, which is called a *daṇḍa* (literally, stick). The number $82 + \frac{27}{60} + \frac{36}{60^2}$ is thus written ८२ । २७ । ३६.

Numerals in astronomical manuscripts

In addition to expressing numbers using the *bhūtasāṅkhyā* system, Sanskrit astronomical and mathematical manuscripts often insert numerals interspersed with the *bhūtasāṅkhyā* words.¹¹⁴ To give an example from the *Siddhāntasundara*:¹¹⁵

sūryasaumyasitaparyayā yuge
pūrṇapūrṇakḥadantasāgarāḥ 4320000 /
ṣaṭsuratṛiśaragiryageṣavaḥ 57753336
śītaraśmibhagaṇā budhaiḥ smṛtāḥ //

In a [*mahā*]yuga there are full-full-space-space-tooth-ocean (i.e., 4,320,000) revolutions of the Sun, Mercury and Venus. The revolutions of the Moon are given by the wise as six-god-three-arrow-mountain-mountain-arrow (i.e., 57,753,336).

Two numbers are given in the verse. The first, 4,320,000, is the number of revolutions of the Sun, Mercury, and Venus in a *mahāyuga* (a period of time spanning 4,320,000 years), and the second, 57,753,336, is the number of revolutions of the Moon in a *mahāyuga*. Both numbers are expressed using the *bhūtasāṅkhyā* system, where “full” and “space” both denote 0, “tooth” denotes 32, “ocean” denotes 4, “god” denotes 33, “arrow” denotes 5, and “mountain” denotes 7. However, in addition, the numbers are written out using numerals.¹¹⁶

The inclusion of the numerals is meant as an aid to the reader. They make it easier to extract astronomical parameters or other numbers while glancing over the text.

Occasionally, numbers are inserted in the absence of a *bhūtasāṅkhyā* word or compound. An example is 2.1.5, which discusses a concept called *śṛṣṭiśaradaḥ* (creation-period). In the *saurapakṣa*, this is considered to be a period of 47,400 divine years (a divine year is 360 of our years) between

¹¹⁴See [86 . 38].

¹¹⁵*Siddhāntasundara* 2.1.18.

¹¹⁶In this case, the numbers are placed after the *bhūtasāṅkhyā* compounds. Though more rare, the numbers are also sometimes written above the *bhūtasāṅkhyā* compound.

the start of the *kalpa* and the commencement of planetary motion. The number 47,400 is not given in the text of the verse, but the scribe generally inserts it after the word *prāguktaśṛṣṭisaradaḥ*.

A quick glance over the critical apparatus of the *Siddhāntasundara* in this dissertation reveals that there is no consistency between the manuscripts when it comes to inserting numerals, nor is there even consistency within any individual manuscript.

Did Jñānarāja himself include the numerals when he wrote the *Siddhāntasundara*, or were they added later by scribes copying the text? There is no way that we can know for sure. In manuscript M₃, which has the commentary of Cintāmaṇi, there is a near absence of numerals in the verses of the *Siddhāntasundara*, but they are present in Cintāmaṇi's comments. This might indicate that the numerals were added later, by commentators or scribes.

Finally, it is worth noting the numbers in the prose solutions provided for the problems phrased using double entendre in the *tripraśnādhikāra*. These numbers are not expressed using words, but simply given in the text as numerals; without them, the solutions are useless. The numbers must therefore have been there from the beginning. Still we find that some of the numbers are omitted in some manuscripts. Some scribes must have missed their importance and omitted them, showing us that just as numerals could find their way into the text, they could also be omitted.

1.3.2 The works of Jñānarāja

When examining manuscript catalogues or other modern works, one generally sees two works attributed to Jñānarāja, which are listed separately: the *Siddhāntasundara* and a work on mathematics referred to as the *Bījādhyaṃya*,¹¹⁷ or the *Sundarasiddhāntabīja*.¹¹⁸ A somewhat ambiguous relationship exists between the *Siddhāntasundara* and this mathematical work, and it is not clear from the modern sources whether the mathematical work is a part of the *Siddhāntasundara*, or whether it is an independent work. Taking a cursory glance at the manuscript evidence, it is not difficult to see why the relationship between the *Siddhāntasundara* and the mathematical work is not entirely clear, for the scribal tradition, which preserved and copied the two works, has consistently handed them down separately. There is no single manuscript that I am aware of that contains them both.

However, a careful examination of the manuscripts reveals that the mathematical work is in fact a part of the *Siddhāntasundara*. As a section of the *Siddhāntasundara*, it is referred to as the *bījagaṇitādhyaṃya* in the following.

In addition to the *Siddhāntasundara* and the *bījagaṇitādhyaṃya*, the *Catalogus Catalogorum* and the *New Catalogus Catalogorum* both attribute a third work, entitled *Yavanaajāṭaka*, to Jñānarāja.

References from primary sources

A verse in the *Sūryodayakāvya* makes a brief mention of *jyotiḥśāstra* works by Jñānarāja:¹¹⁹

¹¹⁷See, for example, [74 . 64]. In [65 . A.3.75], the work is referred to as “. . . a *Bījādhyaṃya* for the *Siddhāntasundara*.”

¹¹⁸See [91 . 94].

¹¹⁹*Sūryodayakāvya* 1.17.

jyotiḥśāstre sundarasiddhāntādiprakartur ...

According to this, in the field of *jyotiḥśāstra*, Jñānarāja is the author of “the *Siddhāntasundara* and so on.” It is possible that the “and so on” of the verse refers to the *bījagaṇitādhyaṃya*, but there is no evidence that Jñānarāja authored other *jyotiḥśāstra* treatises than the *Siddhāntasundara*.

Of greater interest is the first half of a verse from the end of Sūryadāsa’s *Sūryaparakāśa* already quoted above on p. 13:

*siddhāntaṃ suṇḍarākhyam grahagaṇitavidhau jātaka caikam
ekaṃ sāhitye gītaśāstre param idam akarod yaś caturgrantharatnam /*

Here Sūryadāsa credits his father with writing four works: an astronomical treatise entitled *Siddhāntasundara*, as well as three unnamed works on, respectively, horoscopy (*jātaka*), rhetoric (*sāhitya*), and the art of singing (*gītaśāstra*).

When it comes to the two unnamed works on rhetoric and song, nothing can be said beyond what is contained in the statement of Sūryadāsa. I have not been able to find any other references to works by Jñānarāja on these topics.

However, regarding a work on horoscopy authored by Jñānarāja, some things can be said. As noted above, the *Catalogus Catalogorum* attributes a work entitled *Yavana-jātaka* to Jñānarāja,¹²⁰ an attribution that is repeated in the *New Catalogus Catalogorum*.¹²¹ In the latter, it is further stated that this *Yavana-jātaka* of Jñānarāja is quoted in the *Praudhāmanoramā* of Divākara (b. 1606 CE), a commentary on the *Jātakapaddhati*, an astrological work composed by Keśava (fl. 1496/1507 CE).¹²² No further information is given, but the attribution must be based on the following passage from the *Praudhāmanoramā*:¹²³

*jñānarājākṛtayavana-jātaka
lāgnī daśā jīvadaśāprayātā datte narāṇām sudhanāni saukhyam /
sakhyam narendreṇa vivekatā cetyevamādi ...*

In the *Yavana-jātaka* composed by Jñānarāja [it is written]: ...

Here Divākara quotes part of a verse and attributes it to a *Yavana-jātaka* written by Jñānarāja.

This attribution is very interesting. Divākara was a member of a learned family that flourished in Banaras in the 17th century. All of the members of the family, including Divākara, studied the *Siddhāntasundara*, and both Jñānarāja and the *Siddhāntasundara* are mentioned in their works. This includes the *Praudhāmanoramā*, in which Divākara shows his familiarity with the *Siddhāntasundara*, as well as with the works of Cintāmaṇi and Sūryadāsa. For example, Divākara mentions

¹²⁰ [2 . 2.43].

¹²¹ [82 . 7.334].

¹²² Keśava flourished in Nandigrāma, the modern Nandod in Gujarat (see [65 . A.2.65–74; A.3.24; A.4.64–66; A.5.56–59] and [68]). Divākara wrote the *Praudhāmanoramā* in 1626 (see [65 . A.3.106–110; A.4.111; A.5.141–142] and [74 . 125, Table 11]). For editions of the *Jātakapaddhati* with the *Praudhāmanoramā*, see [100] and [54].

¹²³ The *Praudhāmanoramā* on *Jātakapaddhati* 33 (see [100 . 126]).

Jñānarāja as the author of the *Siddhāntasundara* and Cintāmaṇi’s commentary on the same,¹²⁴ comments on a passage in the *Siddhāntasundara* that critiques a rule in the *Siddhāntaśiromaṇi*,¹²⁵ and mentions Sūryadāsa as Jñānarāja’s son.¹²⁶

As promising as this attribution may seem, as it turns out, the verse quoted by Divākara can be traced to the *Vṛddhayavanajātaka* of Mīnarāja.¹²⁷ In other words, the passage quoted in the *Praughamanoramā* is not from a work by Jñānarāja.

Without consulting manuscripts, it is not possible to decide whether the reading “Jñānarāja” is correct, or whether it is a scribal (or editorial) mistake for “Mīnarāja”. Whatever the case may be, I am not aware of any Indic script in which the syllables *jñā* (ज्ञा in the Devanāgarī script) and *mī* (मी in the Devanāgarī script) are easily confused.

1.3.3 The title of the *Siddhāntasundara*

Sūryadāsa calls his father’s astronomical treatise *siddhāntaṃ sundarākhyam*, “a *siddhānta* entitled *Sundara* (literally, Beautiful).” In the two verses of the *Siddhāntasundara* in which Jñānarāja mentions his treatise by name, it is called *Siddhāntasatsundara*,¹²⁸ which can be understood as “a true and beautiful one among the *siddhāntas*” or “a truly beautiful one among the *siddhāntas*”.

Two variant titles, *Siddhāntasundara* and *Sundarasiddhānta*, are used in the manuscripts, as well as in secondary sources, though *Siddhāntasundara* is most often encountered in manuscript colophons.¹²⁹ There appears to be no particular reason why one title is preferred over the other. We will refer to the treatise consistently as the *Siddhāntasundara*.

It may be noted also that Patte uses the title *Siddhāntasundaraprakṛti*, which he translates as *le plaisant fondement du Siddhānta* (the pleasant base of *siddhānta*).¹³⁰ Since none of Patte’s sources about Jñānarāja¹³¹ use this title, and since it is not attested anywhere in the manuscripts of the *Siddhāntasundara* that I have seen, I assume that the title *Siddhāntasundaraprakṛti* is derived from a passage found in some manuscripts of the *Sūryaprakāśa*, in which Sūryadāsa quotes the method for computing a square root given in the *Siddhāntasundara*. Before the quoted verse, we find the words *asmattātacaraṇaiḥ prakṛtisiddhāntasundare*,¹³² which could be taken as indicating that the title of the work composed by Jñānarāja is *Prakṛtisiddhāntasundara*. However, the variant reading *svakṛta* (literally, self-made or made by himself) for *prakṛti* is noted the critical apparatus, yielding

¹²⁴See [100 . 56].

¹²⁵See [100 . 112]. For this passage, see 2.3.45.

¹²⁶See [100 . 38, 102].

¹²⁷Mīnarāja flourished around the first quarter of the 4th century CE (see [65 . A.4.427–429; A.5.310], [73 . 1.24, fn. 75], and [80]). The verse quoted in the *Praughamanoramā* is *Vṛddhayavanajātaka* 7.61 (see [70 . 1.54]).

¹²⁸See 1.1.2. The second verse mentioning the title of the text has already been cited above from the *bījagaṇitādhyāya*.

¹²⁹*Sundarasiddhānta* occurs in the colophon of 1.1 in R₁.

¹³⁰See [61 . 2.28].

¹³¹The sources mentioned by Patte are [3] and [65].

¹³²See [61 . 1.174] for the Sanskrit text, and [61 . 2.293] for the French translation.

the possible reading *asmattātacaraṇaiḥ svakṛtasiddhāntasundare*. This reading is used by Jain in her edition of parts of the *Sūryaparakāśa*.¹³³

1.3.4 Structure of the *Siddhāntasundara*

Table 1.2 shows the contents of the *Siddhāntasundara* according to Pingree.¹³⁴ The same list, with a few minor variations in the titles of some chapters, is given by Sen.¹³⁵ There are similar lists in some manuscript catalogues, but these are based on single manuscripts and will not be considered here.

According to Pingree's table, the *Siddhāntasundara* has two main divisions: the *grahagaṇitādhyāya* (or simply *gaṇitādhyāya*, which is how Dvivedi refers to this part¹³⁶) and the *golādhyāya*. The former consists of 12 sections and constitutes the first part of the text, while the latter consists of 6 sections and constitutes the second and last part of the text.

While this structure is indeed what we find in some manuscripts, a careful investigation of all the available manuscripts shows that it is not that simple. Some manuscripts contain only the *golādhyāya*, others only the *grahagaṇitādhyāya*, but among the manuscripts that contain both, some begin with the *grahagaṇitādhyāya*, others with the *golādhyāya*. In other words, there is no consensus in the tradition itself as to the order of the two parts.

That the *golādhyāya* and the *grahagaṇitādhyāya* have sometimes been handed down separately in the manuscript tradition is not surprising. They can be read separately, and the same phenomenon occurs for the *grahagaṇitādhyāya* and the *golādhyāya* of the *Siddhāntaśiromaṇi*.¹³⁷

In the following, we will discuss and settle the order of the *golādhyāya* and the *grahagaṇitādhyāya* in the text, discuss the contents of each, briefly discuss the *bījagaṇitādhyāya*, and finally establish the textual structure of the *Siddhāntasundara*. Before doing so, however, it is important to bring attention to a passage bearing on the structure of the *Siddhāntasundara* in the commentary *Graha-gaṇitacintāmaṇi* of Cintāmaṇi. Right at the beginning of his commentary on the first chapter of the *grahagaṇitādhyāya*, Cintāmaṇi says that the *golādhyāya* contains six chapters and the next section (what we are calling the *grahagaṇitādhyāya*) contains ten chapters, and it is furthermore clear that Cintāmaṇi considers that the *golādhyāya* constitutes the first part of the *Siddhāntasundara*.¹³⁸

¹³³See [43 . 45 of Sanskrit text], as well as [43 . 95 of apparatus] for the variant readings.

¹³⁴See [65 . A.3.75].

¹³⁵See [91 . 93]. Sen writes that the chapters of the *Siddhāntasundara* are classed mainly under two headings, namely *pātādhyāya* and *golādhyāya*, but this must be an error, as the *pātādhyāya* is a chapter of the text, not a larger section.

¹³⁶See [25 . 57].

¹³⁷See [65 . A.4.299–326, A.5.254–263].

¹³⁸The passage is on f. 1v of manuscript M₃. It is quoted in the catalogue entry of the manuscript (see [102 . 1.4.94–95, entry 291]). The Sanskrit word used by Cintāmaṇi rendered as “section” here is *adhikāra*.

<i>grahagaṇitādhyaṃya</i>	1	<i>madhyamādhikāra</i> (on mean motion)
	2	<i>spaṣṭikaraṇādhyaṃya</i> (on true motion)
	3	<i>tripraśnādhyaṃya</i> (on diurnal motion)
	4	<i>parvasambhūti</i> (on the occurrence of eclipses)
	5	<i>candragrahaṇādhikāra</i> (on lunar eclipses)
	6	<i>sūryagrahaṇādhikāra</i> (on solar eclipses)
	7	<i>grahodayāstādhikāra</i> (on rising and settings of the planets)
	8	<i>nakṣatracchāyāghaṭisāadhanādhikāra</i> (on time from the shadows of stars)
	9	<i>śṛṅgonnatyadhikāra</i> (on elevation of the horns of the Moon)
	10	<i>grahayogādhyaṃya</i> (on planetary conjunctions)
	11	<i>tārāchāyābhadravādya</i> (on stars, shadows, and the polestars)
	12	<i>pātādhyaṃya</i> (on the occurrence of <i>pātas</i>)
<i>golādhyaṃya</i>	1	<i>bhuvanakośādhikāra</i> (on cosmology)
	2	<i>madhyabhuktivāsanādhyaṃya</i> (the rationale of true motion)
	3	<i>chedyake yukti</i> (on drawing projections)
	4	<i>maṇḍalavarṇana</i> (description of the great circles)
	5	<i>yantramālā</i> (on astronomical instruments)
	6	<i>ṛtuvarṇana</i> (description of the seasons)

Table 1.2: Contents of the *Siddhāntasundara* according to Pingree

Chapters of the *Siddhāntasundara*

Each chapter of the *Siddhāntasundara* ends with a verse, the three first quarters of which are:

*itthaṃ śrīmannāganāthātmaajena
prokte tantre jñānarājena ramye /
granthāgārādhārābhūte prabhūte*

Thus [ends such-and-such a section] in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

The fourth line gives the title of the chapter, although in a few instances, due to the amount of text needed to present the chapter, the third line is used for this purpose as well. In the following, we will refer to such a verse as the concluding verse of the relevant chapter.

While the term *adhyāya* is used for the main division of the text into the *golādhya*, the *grahagaṇitādhya*, and the *bījagaṇitādhya*, it is also used interchangeably with the synonym *adhikāra* for the individual sections of the work. This has caused some confusion, such as whether the *pātādhya* is a main division of the text or merely a chapter.¹³⁹ In the following, the term *adhyāya* will consistently be used for the main divisions of the work, while the term *adhikāra* will be used for the sections of each division. This conforms to Cintāmaṇi's usage when, as noted above, he states that the *golādhya* consists of six *adhikāras* and the next section of ten *adhikāras*.

The title of a chapter given in the chapter colophon often differs from what is given in Jñānarāja's concluding verse, and there is variation between the colophons of the different manuscripts as well.

Numbering of chapters is sometimes found in the chapter colophons, but it is not consistent.

Order of the *golādhya* and the *grahagaṇitādhya*

Let us first consider the order of the *golādhya* and the *grahagaṇitādhya* in the manuscripts used for the edition, and then proceed to internal evidence from the text. Note that descriptions and details regarding the manuscript will be given below on p. 50.

Of the manuscripts containing both the *golādhya* and the *grahagaṇitādhya*, three begin with the *golādhya*, namely R₁, V₂, and V₅ (but note that V₅ has an unusual structure), while A, B₁, L, M₁, and M₂ begin with the *grahagaṇitādhya*. For R₃ it is unclear which part begins the manuscript, but it is probably the *grahagaṇitādhya*. On the case of B₃, B₄, and R₂, which are in fact parts of the same manuscript, the situation is also unclear.

The following additional remarks may be made:

1. B₂ has a table of contents on f. 19v. The names *golādhya* and *grahagaṇitādhya* are not used, but what corresponds to our *grahagaṇitādhya* is called *pūrvārdha*, "initial half", while what corresponds to our *golādhya* is called *uttarārdha*, "latter half".

¹³⁹See, e.g., [4. 187, no. 452].

2. R₁ begins with the *golādhya*, which is called *pūrvārdha*, “initial half”. The *grahagaṇitādhya* is not named as such, but merely called *uttarārdha*, “latter half”.
3. The abbreviated title given in the margins of R₂ reads *śi-sū-pū*, where the syllable *pū* most likely stands for *pūrvārdha*, “initial half”. The abbreviated title in the margins of B₃, which is part of the same manuscript as R₂, are *śi-sū-go*, or variations thereof. Note that the numbering of both the *golādhya* and the *grahagaṇitādhya* starts with 1 in this manuscript.
4. In R₃, the two sections are both numbered starting with 1, but the abbreviated titles in the margins are as in B₃ and R₂: for the *grahagaṇitādhya* it is *śi-sū-pū*, where the syllable *pū* most likely stands for *pūrvārdha*, “initial half”, and for the *golādhya* it is *śi-sū-go*, or variations thereof.

While most of the available manuscripts from which an order can be inferred consider the *grahagaṇitādhya* as the first part of the text, the manuscripts B₁, L, M₁, and M₂ are closely related, and thus numbers alone cannot be used as evidence. In addition, Cintāmaṇi’s testimony that the *golādhya* comes first should not be taken lightly. Cintāmaṇi is, after all, Jñānarāja’s son, and one would expect that he knew how the *Siddhāntasundara* was structured. Indeed, the following two pieces of evidence from the *Siddhāntasundara* itself establish that Cintāmaṇi is right.

1. The *golādhya* opens with a number of invocatory and introductory verses that one would expect at the beginning of the work.¹⁴⁰ In contrast, the *grahagaṇitādhya* only has a single invocatory verse at its beginning.¹⁴¹
2. One of the early verses of the *grahagaṇitādhya* states that the 47,400 divine years between the beginning of the *kalpa* and the commencement of planetary motion was mentioned earlier in the work.¹⁴² While no previous mention of this is to be found in the *grahagaṇitādhya*, it is discussed in the *golādhya*.

It is thus established that the *golādhya* constitutes the first part of the *Siddhāntasundara*.

The question remains why the tradition became confused about the order of the two sections. The reason is probably that it is unusual to commence a traditional *siddhānta* with its *gola* section, and some readers and/or scribes must have felt that the *grahagaṇitādhya* was primary.

The *golādhya*

To separate the sections belonging to the *golādhya* from the rest of the work is easy, for each has in its concluding verse the word *golādhya*, “In the *golādhya*”. There are precisely six such sections, in agreement with Cintāmaṇi’s statement. Furthermore, these six sections are as given in Table 1.2. The only exception to this is manuscript V₅, which contains only five sections with

¹⁴⁰See 1.1.1–3.

¹⁴¹See 2.1.1.

¹⁴²See 2.1.5.

the word *golādhya* in the concluding verse (the sixth such chapter is omitted altogether in that manuscript), although including many more chapters under the general heading of *golādhya*. The structure of V₅ will be discussed on p. 35.

The titles given to these six sections by Pingree (see Table 1.2) are correct, although some variations occur in the colophons of the manuscripts.

The *grahagaṇitādhya*

Determining what exactly constitutes the *grahagaṇitādhya* is more difficult. To start with, the term *grahagaṇitādhya* hardly occurs in the manuscripts. None of the concluding verses contain such a designation. In fact, the only occurrence of the term *gaṇitādhya* is in B₄ and R₂ (which are, in fact, two portions of the same manuscript), where a colophon for each chapter containing the word *gaṇitādhya*, “In the *gaṇitādhya*”, has been added in the margins by a different person than the main scribe. It is thus not clear that Jñānarāja intended that there should be a larger grouping of chapters under the heading *grahagaṇitādhya*, although it is likely so, as such a grouping is common in Indian *siddhāntas*.¹⁴³

Nevertheless, it is convenient to have the *grahagaṇitādhya* as a main division of the text, and we will use it as such in the following. It is reasonable to assign all of the sections not belonging to the *golādhya* (or the *bījagaṇitādhya*) to the *grahagaṇitādhya*, but doing so poses a problem: following Cintāmaṇi, we would expect to have ten sections in this section, but Pingree lists twelve sections in the *grahagaṇitādhya*. One of these, however, can quickly be eliminated: the 11th section listed by Pingree. This section is found only in one group of manuscripts (B₁, L, M₁, and M₂), and it turns out to consist of merely the last 13 verses of section 8. For some reason, these verses must have been copied twice and came to be regarded as a section in their own right in that group, whereas they actually belong to an already existing section.¹⁴⁴ This leaves us with 11 sections. As the present critical edition and translation does not cover all of the sections in the *grahagaṇitādhya*, it is not possible to decide here whether one of them is interpolated, whether two of them belong together as one section, or whether all 11 are authentic. The planned complete edition of the *Siddhāntasundara* will address this issue in detail.

The *bījagaṇitādhya*

No careful study of the *bījagaṇitādhya* has been undertaken, but some notes arguing that the text is a part of the *Siddhāntasundara* will be presented here.

1. According to Dikshit, there is a statement in the *Grahagaṇitacintāmaṇi* that the *Siddhāntasundara* contains the *bījagaṇitādhya*,¹⁴⁵ and Sūryadāsa makes a similar statement in the

¹⁴³See, for example, the *Śiṣyadhīvrddhidatantra* (the editions used are [11] and [11]), the *Vaṭeśvarasiddhānta* (the editions used is [94]), and the *Siddhāntaśiromaṇi*.

¹⁴⁴As none of them are among the sections critically edited and translated here, a careful study has not been undertaken, and thus the exact relationship between section 8 and section 11 cannot be ascertained with absolute certainty.

¹⁴⁵See [22 . 2.142].

<i>golādhya</i>	1	<i>bhuvanakośādhikāra</i>	79 verses
	2	<i>madhyabhuktivāsanā</i>	31 verses
	3	<i>chedyake yukti</i>	23 verses
	4	<i>maṇḍalavarṇana</i>	17 verses
	5	<i>yantramālādhikāra</i>	50 verses
	6	<i>ṛtuvarṇanādhikāra</i>	36 verses
<i>grahagaṇitādhya</i>	1	<i>madhyamādhikāra</i>	90 verses
	2	<i>spastādhikāra</i>	50 verses
	3	<i>triprasnādhikāra</i>	46 verses
	4	<i>parvasambhūtyadhikāra</i>	7 verses
	5	<i>candragrahaṇādhikāra</i>	42 verses
	6	<i>sūryagrahaṇādhikāra</i>	16 verses
	7	<i>grahodayāsthādhikāra</i>	19 verses
	8	<i>nakṣatrachāyādhikāra</i>	23 verses
	9	<i>śṛṅgonnatyadhikāra</i>	18 verses
	10	<i>grahayutyadhikāra</i>	9 verses
	11	<i>pātādhikāra</i>	17 verses

Table 1.3: Contents of the *Siddhāntasundara*

Sūryaparakāśa.¹⁴⁶

2. The concluding verses of the sections in the *bījagaṇitādhya* have the same format as those for the *Siddhāntasundara* described above. They do not identify the sections as belonging to a *bījagaṇitādhya*, though.
3. The chapter colophons of the *bījagaṇitādhya* state that the text is a part of the *Siddhāntasundara*.
4. The final verses of the *bījagaṇitādhya* (cited on p. 11) state directly that the title of the work is *Siddhāntasundara*, and these verses are furthermore clearly the concluding verses of the work as a whole, i.e., the concluding verses of the *Siddhāntasundara*.

It is clear from these observations that the *bījagaṇitādhya* is a part of the *Siddhāntasundara*, and furthermore constitutes the final part of that work.

Structure of the *Siddhāntasundara* based on the available manuscripts

The structure of the *Siddhāntasundara* based on the available manuscripts is presented in Table 1.3, where the number of verses in each section is also given.¹⁴⁷

¹⁴⁶See [43 . 45 of Sanskrit text].

¹⁴⁷Note that for the sections not edited here the number of verses may need to be revised in the complete edition of the *Siddhāntasundara*.

The structure of manuscript V₅

The order and allocation of the chapters in manuscript V₅ are substantially different from all other manuscripts. The *golādhyāya* of V₅ consists of the following chapters: (1) *bhuvanakośādhikāra*, (2) *madhyabhuktivāsanā*, (3) *chedyake yukti*, (4) *maṇḍalavarṇana*, (5) *yantramālādhikāra*, (6) *grahodayāstādhikāra*, (7) *nakṣatrachāyādhikāra*, (8) *grahayutyadhikāra*, and (9) *pātādhikāra*. At the conclusion of the *pātādhikāra*, the manuscript has *eṣa golādhyāyaḥ*, indicating that the *golādhyāya* ends there. The *grahagaṇitādhyāya* of V₅ consists of the following chapters: (1) *madhyamādhikāra*, (2) *spaṣṭādhikāra*, (3) *tripraśnādhikāra*, (4) *parvasambhūtyadhikāra*, (5) *candragrahaṇādhikāra*, (6) *sūryagrahaṇādhikāra*, and (7) *śṛṅgonnatyadhikāra*.

It is clear that V₅ contains all of the chapters of the *Siddhāntasundara* given in Table 1.3 with the exception of the *ṛtuvarṇanādhikāra*. Some of the chapters from the *grahagaṇitādhyāya* are furthermore found in the *golādhyāya* of V₅. Considering that none of the other manuscripts have this structure, which contradicts the evidence from Cintāmaṇi regarding the structure of the *Siddhāntasundara*, it is likely that the structure of V₅ is the result of a scribal problem.

While V₅ is the only one of the available manuscripts that has this structure, another manuscript described by Pingree appears to have the same structure. This manuscript is Khasmohor 5591.¹⁴⁸ Like V₅, it begins with the *golādhyāya*, has the words *eṣa golādhyāyaḥ* at the conclusion of that section, and ends with the *śṛṅgonnatyadhikāra*. To establish with certainty that the manuscript displays the same structure as V₅, however, an examination of it would be necessary.

1.3.5 Jñānarāja's sources

Right at the beginning of the *Siddhāntasundara*, Jñānarāja explicitly gives his main source, as well as other treatises considered authoritative by him:¹⁴⁹

*yan nāradāya gaditaṃ caturānanena
jñānaṃ graharkṣagatisaṃsthitirūpam agryam /
śākalyasañjñāmuninā nikhilaṃ nibaddhaṃ
padyais tad eva vivṛṇomi savāsanam svaiḥ //*

*brahmārkenḍuvasiṣṭharomakapulastyācāryagargādibhis
tantrāṇy aṣṭa kṛtāni teṣu gahanaḥ khecārikarmakramaḥ /
tadratnākaravāsanāmbutarāṇe siddhāntapotāḥ kṛtāḥ
śrīmadbhojavarāhaḥ śṛṅgonnatyadhikāraḥ //*

The topmost knowledge concerning the nature of the motion of the planets and the stars that was related to Nārada by the four-faced [Brahman] was written down in its entirety by the sage bearing the name Śākalya. In my own verses, I am presenting precisely that [knowledge], accompanied by demonstrations.

¹⁴⁸Described in [78 . 18–19, no. 41].

¹⁴⁹See 1.1.3–4.

Eight *tantras* were written by Brahman, Sūrya, Candra, Vasīṣṭha, Romaka, Pulastya, Bṛhaspati, and Garga. The difficult method of planetary computations is [given] in them. For crossing over the ocean [of this difficult science] by means of demonstrations [of the formulae] of their [i.e., the *tantras*] mine of jewels, boats [in the form] of *siddhāntas* were made by Bhojarāja, Varāhamihira, Jīṣṇu's son [Brahmagupta], Caturveda [Pṛthūdaka-svāmin], Āryabhaṭa, and the good Bhāskara [II].

A verse from the *grahagaṇitādhyaṃya* is important as well:¹⁵⁰

*brahmā prāha ca nārādāya himagur yac chaunakāyāmalaṃ
māṇḍavyāya vasiṣṭhasaṅjñakamuniḥ sūryo mayāyāha yat /
pratyakṣāgamayuktiśālī tad idaṃ śāstraṃ vihāyānyathā
yat kurvanti narā na nirvahati tad vijñānaśūnyāś ciraṃ //*

The pure [teaching] that Brahman spoke to Nārada, Candra spoke to Śaunaka, the sage Vasīṣṭha spoke to Māṇḍavya, and Sūrya spoke to Maya is full of reasoning based on perception and traditional teachings. Whatever men do differently after abandoning this science, that ceases to produce correct results over time, because they are devoid of [proper] knowledge.

The *Brahmasiddhānta* of the Śākalyasaṃhitā

The Śākalya that Jñānarāja refers to in the first verse is the legendary author of a *Śākalyasaṃhitā*. The lecture of Brahman to Nārada, which Śākalya is said to have recorded, is the professed contents of an astronomical treatise bearing the title *Brahmasiddhānta*. According to the colophons of the *Brahmasiddhānta*, the text is the second *praśna* (literally, question, but also used for a short section of a work) of the *Śākalyasaṃhitā*.¹⁵¹ No other parts of a *Śākalyasaṃhitā* are known.

Jñānarāja explicitly says in the first of the verses cited from the *golādhyaṃya* that what he has put into his own verses and augmented by adding *vāsanās* is the astronomical knowledge that was spoken by Brahman to the sage Nārada and written down by the sage Śākalya. This shows that Jñānarāja's main source for composing the *Siddhāntasundara* is the *Brahmasiddhānta*.

The tradition of the eight *siddhāntas*

The *Brahmasiddhānta* mentions eight personages as the authorities from whom the science of astronomy originated:¹⁵²

*etac ca mattaḥ śītāṃśoḥ
pulastyāc ca vivasvataḥ /*

¹⁵⁰See 2.1.8.

¹⁵¹See [65 . A.4.259].

¹⁵²*Brahmasiddhānta* 1.9–10.

romakāc ca vasiṣṭhāc ca
 gargād api bṛhaspateḥ //
 aṣṭadhā nirgataṃ śāstram
 ...

This science [of astronomy] has come forth in eight ways: from me [Brahman], from Candra, from Pulastya, from Sūrya, from Romaka, from Vasiṣṭha, from Garga, and from Bṛhaspati.

What is alluded to here is a tradition that the science of astronomy was originally given to mankind by eight deities and ancient sages in eight treatises. Jñānarāja names the same eight deities and ancient sages as the originators of eight *tantras*: (1) Brahman, (2) Sūrya, (3) Candra, (4) Vasiṣṭha, (5) Romaka, (6) Pulastya, (7) Bṛhaspati, and (8) Garga.

Certain manuscripts of the *Brahmasiddhānta* furthermore connect these eight names to sections in the *Śākalyasaṃhitā*, of which the *Brahmasiddhānta* considers itself to be the second *praśna*. While examining a South Indian manuscript of the *Brahmasiddhānta*, Dhavale discovered that it contained a large number of verses not found in the North Indian manuscripts at his disposal.¹⁵³ Among these verses, he found some giving details about eight *praśnas* of the *Śākalyasaṃhitā* as follows.¹⁵⁴ The first *praśna* pertains to Sūrya, the second to Brahman, the third to Puliśa (or Pauliśa), the fourth to Soma (i.e., Candra), the fifth to Romaśa, the sixth to Garga, the seventh to Bṛhaspati, and the eight to Vasiṣṭha.

The names Pulastya and Puliśa or Pauliśa are often used interchangeably when referring to certain Sanskrit astronomical treatises. The Pulastya mentioned by Jñānarāja is thus likely the same as the Puliśa to which the third *praśna* of the *Brahmasiddhānta* is ascribed. Similarly, the names Romaka and Romaśa are used interchangeably.

For identifying the eight treatises, the following can be said. One of them, of course, is the *Brahmasiddhānta*, the identity of which is established without a doubt by the first verse quoted from the *golādhyāya*. Furthermore, the verse quoted from the *grahagaṇitādhyāya* helps us identify three more of the eight treatises, for a lecture on astronomy by Soma to Śaunaka is recorded in a treatise entitled the *Somasiddhānta*. Similarly, astronomical lectures by Vasiṣṭha to Māṇḍavya and by Sūrya to Maya are recorded in the *Vasiṣṭhasiddhānta* and the *Sūryasiddhānta*, respectively.

The titles of the remaining four treatises would then be *Romakasiddhānta*, *Pulastyasiddhānta*, *Bṛhaspatisiddhānta*, and *Gargasiddhānta*, assuming that they, like the first four, are called *siddhāntas* in the tradition. Note, however, that the latter three are rather doubtful, as will be seen in the descriptions of each treatise below. Table 1.4 gives a list of the eight treatises ordered according to the *praśnas* of the *Śākalyasaṃhitā*. The deity or sage refers to the eight names given by Jñānarāja,

¹⁵³See [20 . 37].

¹⁵⁴See [20 . 38]. Aufrecht cites a passage from the *Saurabhāṣya* of Nṛsiṃha, according to which the *Sūryasiddhānta*, the *Brahmasiddhānta*, the *Pauliśasiddhānta*, and the *Somasiddhānta* are the first, second, third, and fourth *praśnas*, respectively, of an unnamed work (see [1 . 43, entry R. 15. 103.]).

<i>Praśna</i>	Deity or sage	Treatise	Teacher	Student(s)
1	Sūrya	<i>Sūryasiddhānta</i>	Sūrya	Maya
2	Brahman	<i>Brahmasiddhānta</i>	Brahman	Nārada
3	Pulastya	<i>Pulastyasiddhānta</i>	—	—
4	Soma	<i>Somasiddhānta</i>	Soma	Śaunaka
5	Romaka	<i>Romaśasiddhānta</i>	Viṣṇu	Vasiṣṭha and Romaśa
6	Garga	<i>Gargasiddhānta</i>	—	—
7	Bṛhaspati	<i>Bṛhaspatisiddhānta</i>	—	—
8	Vasiṣṭha	<i>Vasiṣṭhasiddhānta</i>	Vasiṣṭha	Māṇḍavya

Table 1.4: The eight astronomical treatises

and the treatise to the corresponding astronomical text. Finally, where known, the teacher and student(s) of each treatise is given.

The number eight is significant in Indian history. There are, for example, eight limbs in the system of *yoga*, eight limbs in the system of *āyurveda* (traditional Indian medicine), and eight *aṣṭakas* (literally, eighths) of the *R̥gveda* (an ancient collection of hymns sacred in Hinduism). It is therefore possible that the three doubtful treatises, the *Pulastyasiddhānta*, the *Gargasiddhānta*, and the *Bṛhaspatisiddhānta* never existed, but were added to the list to bring the number of treatises up to the significant number eight. However, it is also possible that they did exist, but perhaps never gained great popularity and hence are no longer extant.

It should be noted that there is sometimes more than one treatise with the same name. Varāhamihira, in his *Pañcasiddhāntikā*, describes five astronomical works, among which are a *Sūryasiddhānta*, a *Paulīśasiddhānta*, a *Romakasiddhānta*, and a *Vasiṣṭhasiddhānta*.¹⁵⁵ These are not the same treatises as those referred to by Jñānarāja. For this reason, the *Sūryasiddhānta* relevant to us is often referred to as the modern *Sūryasiddhānta*.

The distinction between *apauruṣeya* and *pauruṣeya*

The authors of the eight treatises that are taken as authoritative by Jñānarāja are deities or ancient sages, and hence divine. This means that the treatises are considered *apauruṣeya*, or not derived from human beings. The works composed by Brahmagupta, Bhāskara II, and others, said by Jñānarāja to be ancillary to the eight *apauruṣeya* treatises, are considered *pauruṣeya*, or derived from human beings. Jñānarāja draws a clear distinction between the two. The former are authoritative, the latter merely aiding us in understanding them. It should be noted, though, that the terms *apauruṣeya* and *pauruṣeya* are used by Dikshit,¹⁵⁶ but not by Jñānarāja.

It is interesting that Jñānarāja refers to the eight *apauruṣeya* treatises as *tantras*, while calling the *pauruṣeya* works *siddhāntas*. As we will see below, the divine treatises in question are generally called *siddhāntas*, not *tantras*. Perhaps Jñānarāja used the term *tantra* to highlight clearly the

¹⁵⁵See [74 . 11].

¹⁵⁶See [22 . 2.27].

distinction between the two categories.

Brief notes on each of the eight treatises will now be given.

The modern *Sūryasiddhānta*

The *Sūryasiddhānta* is a well-known Sanskrit astronomical treatise from about 800 CE.¹⁵⁷ It has been edited and published many times,¹⁵⁸ and English translations of the text are available as well.¹⁵⁹ It has the form of a lecture on astronomy by the sun-god Sūrya to Maya, and is the primary text of the *saurapakṣa*.¹⁶⁰

The *Brahmasiddhānta*

The *Brahmasiddhānta* has been edited and published twice.¹⁶¹ While its title suggests that it belongs to the *brāhmapakṣa*, it is in fact a *saurapakṣa* text.¹⁶² It is not clear when the *Brahmasiddhānta* was written, but Pingree suggests that it was in the period between the composition of the *Siddhānta-śiromaṇi* of Bhāskara II and the composition of the *Siddhāntasundara*.¹⁶³ As noted by Dikshit, the *Brahmasiddhānta* treats the subject of religion, an unusual feature for an astronomical treatise, although he does not specify exactly what this entails.¹⁶⁴

The *Pulastyasiddhānta*

It was noted above that the names Pulastya and Puliśa are used interchangeably. Therefore, the title of this treatise could also be *Pauliśasiddhānta*. Apart from the *Pauliśasiddhānta* mentioned by Varāhamihira in the *Pañcasiddhāntikā*, there is a later *Pauliśasiddhānta*, but Pingree notes that this is an *ārdharātrikapakṣa* text, and thus likely not the text referred to here.¹⁶⁵ Pingree mentions a *Paulastyasiddhānta* in *Census of the Exact Sciences in Sanskrit*, but he considers it “[p]robably fictional . . .”¹⁶⁶

¹⁵⁷See [74 . 23].

¹⁵⁸See, e.g., [39].

¹⁵⁹See, e.g., [9].

¹⁶⁰See [71 . 608–609].

¹⁶¹The *Brahmasiddhānta* was first edited and published by Dvivedi in [26], and later a critical edition was published by Dhavale in [21]. See also [20], [22 . 2.49–50], [71 . 613], and [65 . A.4.259–260, A.5.240–241].

¹⁶²See [74 . 26] and [65 . A.4.259].

¹⁶³See [74 . 26].

¹⁶⁴See [22 . 2.49].

¹⁶⁵For the later *Pauliśasiddhānta* see [63]. Pingree says that it is an *ārdharātrikapakṣa* text (see [63 . 173].

¹⁶⁶See [65 . A.4.223].

The *Somasiddhānta*

The *Somasiddhānta* has been edited and published once.¹⁶⁷ It belongs to the *śaurapakṣa*.¹⁶⁸ Like the *Brahmasiddhānta*, Pingree believes that it was composed in the period between the composition of the *Siddhāntaśiromaṇi* of Bhāskara II and the composition of the *Siddhāntasundara*.¹⁶⁹ A commentary on the text was composed in about 1400 CE.¹⁷⁰ It has the form of a lecture on astronomy by the moon-god Candra (also known as Soma) to the sage Śaunaka.

The *Romakasiddhānta*

The *Romakasiddhānta*, also known as the *Romaśasiddhānta*, has never been published, but Dikshit gives a description of the work.¹⁷¹ Photocopies of three manuscripts of the *Romakasiddhānta* are available to me thanks to Pingree.¹⁷² The treatise has the form of the deity Viṣṇu instructing the two sages Vasiṣṭha and Romaśa in astronomy.¹⁷³

The *Gargasiddhānta*

Various works on divination, astrology, and astronomy are ascribed to the sage Garga,¹⁷⁴ among which a *Gargasamhitā* in the form of a dialogue between Bhāradvāja and Garga might be relevant here.¹⁷⁵ When it comes to a *Gargasiddhānta*, Pingree believes that it probably never existed.¹⁷⁶

The *Bṛhaspatīsiddhānta*

Pingree does not list a *Bṛhaspatīsiddhānta*, nor a *Bārhaspatyasiddhānta* (*bārhaspatya* meaning “relating to Bṛhaspati”) in *Census of the Exact Sciences in Sanskrit*. A *Bṛhaspatīsamhitā*, also called *Bārhaspatya*, in the form of a conversation between Bṛhaspati and Nārada, is listed,¹⁷⁷ but this work

¹⁶⁷See [26].

¹⁶⁸See [71 . 612].

¹⁶⁹See [74 . 26].

¹⁷⁰See [71 . 612].

¹⁷¹See [22 . 2.34–35,48]. See also [65 . A.5.517–519].

¹⁷²The three manuscripts are Pingree 42, Pingree 43, and Pingree 44 (see [65 . A.5.518]).

¹⁷³See [22 . 2.34–35] and [21 . xvii]. Pingree gives the speaker of the treatise as Nārada or Nārāyaṇa (Nārāyaṇa is another name of the deity Viṣṇu) and the student as Vasiṣṭha Romaśamuni (see [65 . A.5.518]). However, while the manuscripts Pingree 43 and Pingree 44 open with Nārada speaking (the manuscript Pingree 42 opens with Nārāyaṇa speaking), it is clear from what follows (the beginning of the *Romakasiddhānta* is quoted and translated by Dikshit in [22 . 2.34–35]) that it is the deity Viṣṇu that is instructing Vasiṣṭha and Romaśa (not Vasiṣṭha Romaśamuni, as one person).

¹⁷⁴See [65 . A.2.116–120].

¹⁷⁵See [65 . A.2.118].

¹⁷⁶See [65 . A.2.120].

¹⁷⁷See [65 . A.4.249–250, A.5.235–236].

deals with divination.¹⁷⁸ According to Aufrecht, a *Bṛhaspatīsiddhānta* is cited in the *Saurabhāṣya* of Nṛsiṃha.¹⁷⁹

The *Vasiṣṭhasiddhānta*

There are two extant *Vasiṣṭhasiddhāntas* that are relevant to us:¹⁸⁰ a *Vṛddhavasīṣṭhasiddhānta* and a *Laghuvasiṣṭhasiddhānta* (*vṛddha* meaning “larger” and *laghu* meaning “shorter”). The latter is often referred to simply as the *Vasiṣṭhasiddhānta*, and we will follow that convention here. Both texts have been edited and published once.¹⁸¹ The *Vṛddhavasīṣṭhasiddhānta* has the form of a dialogue between Vāmadeva and Vasiṣṭha,¹⁸² while the *Vasiṣṭhasiddhānta* has the form of a lecture on astronomy given by Vasiṣṭha to Māṇḍavya.¹⁸³ Since Jñānarāja refers to a lecture by Vasiṣṭha to Māṇḍavya, it is clear that he is referring to the *Vasiṣṭhasiddhānta*, not the *Vṛddhavasīṣṭhasiddhānta*.

Other traditions of *siddhāntas*

According to another Indian tradition, there are nine canonical *siddhāntas*. As noted by Burgess,¹⁸⁴ the *Śabdakalpadruma*, a Sanskrit encyclopedia, lists nine astronomical treatises under the entry *siddhānta*:¹⁸⁵ (1) the *Brahmasiddhānta*, (2) the *Sūryasiddhānta*, (3) the *Somasiddhānta*, (4) the *Bṛhaspatīsiddhānta*, (5) the *Gargasiddhānta*, (6) the *Nāradasiddhānta*, (7) the *Parāśarasiddhānta*, (8) the *Pulastyasiddhānta*, and (9) the *Vasiṣṭhasiddhānta*. Except that the *Romakasiddhānta* is removed and *siddhāntas* of Nārada and Parāśara are added, this list corresponds to the names given in the *Brahmasiddhānta*.¹⁸⁶ Pingree writes that Nārada is the “[a]lleged author of a *Nārada-siddhānta*”¹⁸⁷ and that the *Parāśarasiddhānta* is a conversation between some sages and Parāśara.¹⁸⁸ There are, in addition, other similar *siddhāntas*, such as the *Vyāśasiddhānta*.¹⁸⁹

¹⁷⁸See [74 . 76].

¹⁷⁹See [1 . 43].

¹⁸⁰See [74 . 26] and [65 . A.5.607–609].

¹⁸¹For the edition of the *Vṛddhavasīṣṭhasiddhānta*, see [27]. For the edition of the *Vasiṣṭhasiddhānta*, see [28]. There is also an article by Rai dealing with the *Vṛddhavasīṣṭhasiddhānta* (see [83]).

¹⁸²See [65 . A.5.608].

¹⁸³See [65 . A.5.608].

¹⁸⁴See [9 . 418].

¹⁸⁵See [101 . 5.351]. This list in the same order is also mentioned by Das (see [14 . 200–201]), who says that it is given in the *Ā’in-i Akbarī* of Abu’l-Fazl (1551–1602), the vizier of Emperor Akbar. However, while the *Ā’in-i Akbarī* mentions the *Sūryasiddhānta* (see, for example, [33 . 2.326, 2.332]), I have not been able to find mention of the remaining titles in Gladwin’s translation (see [33]).

¹⁸⁶For the *Parāśarasiddhānta*, see [65 . A.4.198]. It is cited in the *Saurabhāṣya* of Nṛsiṃha (see [1 . 43]). For the *Nāradasiddhānta*, see [65 . A.3.149].

¹⁸⁷See [65 . A.3.149].

¹⁸⁸See [65 . A.4.198].

¹⁸⁹Mentioned by Bhāu Dājī (see [13 . 398]). For more information on the *Vyāśasiddhānta*, see [65 . A.5.754] and [52 . 360].

Other sources for the *Siddhāntasundara*

Other than the *Brahmasiddhānta* and the other related treatises, Jñānarāja mentions a number of other writers of astronomical texts:

1. Āryabhaṭa, a famous Indian astronomer who was born in 476 CE, is the author of the *Āryabhaṭīya* and the originator of the *āryapakṣa* and the *ārdharātrikapakṣa*,¹⁹⁰
2. Brahmagupta, another famous Indian astronomer born in 598 CE, and author of the *Brāhmasphuṭasiddhānta*,¹⁹¹
3. Bhojarāja, who flourished in the first half of the 11th century CE, and is the author of a now lost *Ādityapratāpasiddhānta* and a *karāṇa* entitled *Rājamarṇāṅka*,¹⁹²
4. Varāhamihira, who flourished around 550 CE, and who wrote extensively on astronomy and astrology,¹⁹³
5. Bhāskara II, who was born in 1114 CE, and the author of many important works on astronomy and mathematics,¹⁹⁴
6. Pṛthūdakasvāmin, who flourished in 864 CE, and who wrote an important commentary on Brahmagupta's *Brāhmasphuṭasiddhānta*,¹⁹⁵ and
7. Dāmodara.¹⁹⁶

While Āryabhaṭa, Bhojarāja, Brahmagupta, and Varāhamihira are mentioned as examples of authors of astronomical treatises, there are no indications that their works were used by Jñānarāja while composing the *Siddhāntasundara*; he presumably mentioned them due to their status in Indian astronomy. Jñānarāja must have read the *Brāhmasphuṭasiddhānta* of Brahmagupta, though, for the commentary by Pṛthūdakasvāmin on this text is cited.¹⁹⁷ Jñānarāja clearly read the *Siddhāntaśiromaṇi* of Bhāskara II. Both Bhāskara II and the *Siddhāntaśiromaṇi* are mentioned by name, and the *Siddhāntaśiromaṇi* is cited.¹⁹⁸ In the *Siddhāntasundara*, Jñānarāja cites some *bīja* corrections from Dāmodara (see 2.1.83–84 and the commentary thereon).

¹⁹⁰See [64], [65 . A.1.50–53, A.2.15, A.3.16, A.4.27–28, A.5.16–17], and [79]).

¹⁹¹See [65 . A.4.254–257, A.5.239–240]. The editions of the *Brāhmasphuṭasiddhānta* used are [29] and [41].

¹⁹²See [65 . A.4.336–339, A.5.266–267]).

¹⁹³See [65 . A.5.563–595], [69], and [81].

¹⁹⁴See [65 . A.4.299–326, A.5.254–263].

¹⁹⁵See [65 . A.4.221–222, A.5.224]), wrote an important commentary on Brahmagupta's *Brāhmasphuṭasiddhānta*, parts of which have been edited (see [41]).

¹⁹⁶See [22 . 2.125–127]. See also [71 . 614], where Pingree says that the *bījas* of Dāmodara are mentioned in the *Siddhāntasārvabhauma*; Jñānarāja is mentioned in the commentary to *Siddhāntasārvabhauma* 119–120.

¹⁹⁷See 1.1.23.

¹⁹⁸See, for example, 1.1.32.

Mathematical sources

When it comes to the mathematics of the *bījagaṇitādhyaṃya*, Datta notes that Jñānarāja refers his readers to the *Bījagaṇitāvataṃsa*, a work on algebra by Nārāyaṇa Paṇḍita.¹⁹⁹ In addition, Jñānarāja repeats a method for solving quadratic equations originally given by Śrīdhara, who flourished around 750 CE and is the author of a now lost mathematical work (Śrīdhara’s method is also given by Bhāskara II and Sūryadāsa).²⁰⁰ Furthermore, Jñānarāja gives the same methods as Bhāskara II for solving quadratic equations.²⁰¹ For the *kuṭṭaka* (literally, pulverizer), a method for solving indeterminate equations of the form $a \times x - b \times y = \pm c$, where a , b , and c are given positive integers, Jñānarāja gives a rule similar to those of previous writers such as Brahmagupta and Bhāskara II.²⁰² For solving simultaneous indeterminate equations, Jñānarāja gives a rule similar to one given by Bhāskara II.²⁰³ For the *vargaprakṛti* and *cakravāla* (that is, respectively, the indeterminate equation $N \times x^2 + 1 = y^2$, where N is a given positive integer that is not a square, and its solution through a “cyclic method”), Jñānarāja gives rules similar to those given by Bhāskara II and Nārāyaṇa Paṇḍita.²⁰⁴

Islamic influence in the *Siddhāntasundara*

As we have seen, the region in which Jñānarāja lived had been under Islamic control for a long time when the *Siddhāntasundara* was written.

Prior to the time of Jñānarāja, Islamic influence on Indian astronomy was either computational (i.e., the only influence was on computation in formulae), as seen in the works of Muñjāla (fl. about 932 CE) and Śrīpati (fl. between 1039 and 1056 CE) from the 10th and 11th centuries CE, or related to the introduction of the astrolabe into Western India in the 14th century CE.²⁰⁵

In a survey of sixteenth century Sanskrit astronomical treatises, including the *Siddhāntasundara*, from Western and Northern India, Pingree finds no reflections of Islamic astronomy, and he further notes that the next wave of Islamic influence on Indian astronomy occurred under the Moghuls, after the time of Jñānarāja.²⁰⁶ However, when he engaged me in working on the *Siddhāntasundara*, he told me that he was curious whether a careful investigation would reveal Islamic influence.

On the whole, my research has shown that Pingree’s assessment is correct: Jñānarāja follows the Indian tradition both when it comes to mathematical formulas and theories about the cosmos. There are, however, two passages of interest, one dealing with what we today call Heron’s method for finding square roots, the other with a cosmological idea involving a crystalline sphere.

¹⁹⁹See [16 . 476]. For an edition and English translation of the *Bījagaṇitāvataṃsa*, see [40].

²⁰⁰See [17 . 65].

²⁰¹See [17 . 69].

²⁰²See [17 . 92–93, 116].

²⁰³See [17 . 128].

²⁰⁴See [17 . 144, 148].

²⁰⁵See [72 . 317–318]. For Muñjāla, see [65 . A.4.435–436, A.5.312]. For Śrīpati, see [74 . 25].

²⁰⁶See [72 . 319].

Heron's method

Twice in the *Siddhāntasundara*, Jñānarāja gives a verse containing a method for computing the square root of any given positive number, once in the *grahagaṇitādhyaṃya*²⁰⁷ and once in the *bījagaṇitādhyaṃya*.²⁰⁸ The verse, as found in the *grahagaṇitādhyaṃya*, reads:

āsannamūlena hṛtāt svavargāl
labdhena mūlaṃ sahitaṃ dvibhaktam /
bhavaṭ tad āsannapadaṃ tato 'pi
muhur muhuḥ syāt sphuṭamūlam evam //

An [approximate value of the desired] square root is increased by the result of the division of the given square [i.e., the number whose square root we are seeking] by the approximate square root. [The result] is divided by 2. That is the [new] approximate square root. Then [the process is repeated] again and again. In this way, the correct square root [is found].

For the mathematical explanation of the verse, which is cited (from the *bījagaṇitādhyaṃya*) by Sūryadāsa in the *Sūryaprakāśa*,²⁰⁹ the reader is referred to the commentary on it. Here we will restrict ourselves to its historical significance.

The method described in the verse is an ancient one given by Heron of Alexandria in his *Metrica*;²¹⁰ we will refer to it in the following as Heron's method. Heron's method allows one to compute the square root of any given positive number by means of an initial approximation and iteration. In Jñānarāja's verse describing the method, iteration is prescribed until the square root is exact. This verse has often been mentioned in modern studies,²¹¹ and from modern surveys of methods for computing square roots in India, it is found that the *Siddhāntasundara* is the first Indian treatise to record the method.²¹² Before Jñānarāja, the methods given in various mathematical works were not based on iteration, but were closed formulae.

Noting that Jñānarāja flourished at a time when Islamic culture penetrated into India, Chakrabarti suggests that Jñānarāja borrowed the method "...from the Arabs."²¹³ Regarding Islamic involvement with the method, Smyly, without giving any references, says that the method "...was known

²⁰⁷See 2.2.22.

²⁰⁸See [43 . 13–14] for the details on the occurrence of the verse in one manuscript of the *bījagaṇitādhyaṃya* (Berlin 833).

²⁰⁹See [43 . 45 of Sanskrit text] and [61 . 1.174].

²¹⁰See [6 . 35].

²¹¹See, e.g., [17 . 2.28] (where an English translation is given, but no Sanskrit or other reference) and [3 . 101] (Sanskrit given with a mistake). Note that Datta and Singh seems to have been first to cite the verse, and later studies refer to them.

²¹²See [15], [18], and [19].

²¹³ [10 . 56].

by the Arabs, but seems to have been subsequently forgotten,”²¹⁴ and Smith notes that Rhabdas²¹⁵ followed an “Arabic method” when computing a square root using Heron’s method.²¹⁶ However, I cannot find any statement to the effect that the method is “Arabic” in the source referred to by Smith.²¹⁷ In fact, Youschkevitch, in his survey of Arabic mathematics, does not mention any methods for extracting square roots based on iteration,²¹⁸ and Berggren says that he is not aware of evidence that Islamic writers used Heron’s method.²¹⁹

In conclusion, it is highly unlikely that Jñānarāja learned Heron’s method from Islamic sources. First of all, as shown above, this particular method was not used by Islamic mathematicians, and secondly, formulae for computing square roots as well as iterative methods have been known in India since early times.

Crystalline spheres

There is a passage in the *Siddhāntasundara* in which Jñānarāja betrays a knowledge of foreign cosmology:²²⁰

*kecit kācasamācchabhūtalacaladgolān samantād bhuvaś
candrajñāsphuḍidarkabhaumavibudhācāryārkihānāṃ jaguḥ /
tatpakṣe pratimaṇḍalasthitivaśān nīcoccapātādikam
yojyaṃ tadbhramaṇam dhruveṇa na mataṃ naḥ kalpanāgauravāt //*

In the verse, Jñānarāja tells us that some people hold the idea that for each of the planets and for the stars there are spheres that are transparent like crystal rotating around the Earth.²²¹ Using weight as his argument, Jñānarāja rejects this idea of crystalline spheres.

Who these “some people” are is not revealed by Jñānarāja, and, unfortunately, Cintāmaṇi’s commentary on the verse is not very helpful. Cintāmaṇi merely says: *spaṣṭārtham*, “The meaning is clear.”²²²

²¹⁴See [96 . 18].

²¹⁵Nicolas Rhabdas was a Byzantine mathematician who flourished in the 14th century CE (see [6 . 35]). Chakrabarti, curiously, writes Kabdās instead of Rhabdas in [10 . 56].

²¹⁶See [95 . 254–255].

²¹⁷Smith’s source is [97 . 185].

²¹⁸See [108 . 76–80].

²¹⁹See [6 . 35]. Berggren further says that Rhabdas and other Byzantine mathematicians possibly learned Heron’s method from Heron’s work. It may be worth noting as well that Berggren reports that Al-Qalaṣādī, a fifteenth-century Muslim mathematician from Granada, recommends iterating the approximation $\sqrt{a^2 + r} = a + \frac{r}{2 \times a}$ once when $r > a$, yielding the new approximation $\sqrt{a^2 + r} = a + \frac{r}{2 \times a} - \frac{(r/(2 \times a))^2}{2 \times (a + r/(2 \times a))}$ (see [6 . 34]).

²²⁰*Siddhāntasundara* 1.2.9. The passage is the topic of [48].

²²¹Since Jñānarāja says that the spheres are “transparent like crystal” indicates that they are not made of crystal, but merely share the quality of transparency with crystal.

²²²Reading based on V₁ (f. 50v).

Although neither Jñānarāja nor Cintāmaṇi identifies the source(s), it is clear that the idea expressed in the verse is derived from a foreign tradition. First of all, the idea of crystalline spheres is not found in the Indian tradition. Secondly, the idea of a crystalline sphere has been identified as being *yavana* (originally Ionian or Greek, but later a person from the regions west of India) by Nṛsiṃha in his *Vāsanāvērttika* commentary on Bhāskara II's *Siddhāntaśiromaṇi*, and Pingree identifies *yavana* as Islamic.²²³ Whatever the case may be, it is clear that the Indian tradition itself considered this idea to have come from outside. Regarding Nṛsiṃha's discussion of the idea, to be more precise, he argues that the *yavana* idea that there is a crystalline sphere supporting the sphere of the constellations and enabling it to rotate daily from east to west is incorrect. His argument against it is that the crystal could not bear such a weight.

It is worth noting the word *pakṣa* in the verse. While it may mean “an opinion,” it is also used to refer to the Indian schools of astronomy, such as the *brāhmapakṣa* or the *saurapakṣa*. It is not clear which the word refers to here. I am not aware of any Indian school of astronomy or members of such that subscribes to the idea of one or more crystalline spheres, so presumably the intended meaning is merely “an opinion.”

The problem is that there is no reference to a crystalline sphere or crystalline spheres in the Islamic literature.²²⁴ The idea that one of the spheres (the 9th) is crystalline is a European idea, based on an interpretation of a passage in Ezekiel.²²⁵ The word *yavana* could refer to Europeans, although a reference to Muslims is more likely. Still, this opens up the intriguing possibility that Jñānarāja was aware of a European cosmological idea.

1.3.6 Special features of the *Siddhāntasundara*

As we have seen, the *Siddhāntasundara* has the same structure as older *siddhāntas*, especially the *Siddhāntaśiromaṇi*, but there are some unique features as well.

One such unique feature is the inclusion of peculiar problems in the *tripraśnādhikāra*. As explained on p. 6, these sample problems that Jñānarāja has included in the *tripraśnādhikāra* are poetic and phrased using double entendre: one level of meaning provides a narrative, the other provides the technical information necessary to solve a given problem. Problems are not otherwise found in *siddhāntas*, indicating that there was not a tradition of including them, but these problems stand out beyond their mere presence. They are phrased poetically using double entendres (*śleṣa*). Each problem poses a question that is to be answered based on the remainder of the verse. However, the remainder has two layers of meaning: one provides a narrative, the other technical information.

This is best illustrated by an example:²²⁶

siṃhāsanāsīnam inatvam āptam

²²³See [72 . 320–321], but note that the title of Nṛsiṃha's commentary is given incorrectly as Marīci in [72 . 321, fn. 34] (Marīci is the title of Muṇiśvara's commentary on the *Siddhāntaśiromaṇi*).

²²⁴Personal communications with Jamil Ragep and others.

²²⁵See [36 . 160–162] for the crystalline sphere in Europe.

²²⁶See 2.3.17.

mitraṃ viditvādyutir uttarāśām /
yāto 'bhavat pūrvanṛpaprabho yas
tasyāśūpūṃso vada yānamānam //

[Narrative translation:] Tell [me] the length of the journey of the swift man, who, upon learning that his friend had gained kingship and was sitting on the lion's seat [i.e., the throne], deprived of luster went north [to a place where] he had the luster of a former king.

[Technical translation:] Tell [me] the measure of the journey of the swift man, who, upon learning that the sun had attained lordship sitting in the lion's seat [i.e., was in Leo], cast no shadow and who went north [until] he had a shadow of [length] 16 [falling] towards the east.

As can be seen, the narrative itself does not provide the information needed to solve the question posed; to solve it, the words of the verse have to be interpreted differently, yielding the technical translation given, which provides the necessary information. For the technical aspects of the verse and the solution to the problem, the reader is referred to the translation and commentary (see p. 183).

As a further example, consider the first quarter of another such verse:²²⁷

nakramukhe 'stamite sati haṃse

[Narrative translation:] When the good goose perished in the mouth of a crocodile. . .

[Technical translation:] When the sun, being in the beginning of Capricorn, was setting. . .

The *ṛtuvarṇanādhikāra*

Bhāskara II was the first astronomer to include a poetic description of the seasons in an astronomical treatise.²²⁸ The poem in the *Siddhāntaśiromaṇi* is based on the *Ṛtusaṃhāra* (literally, Exposition of the Seasons) by the renowned poet Kālidāsa. Following Bhāskara II, Jñānarāja also included a poetic description of the seasons in the *Siddhāntasundara*, namely the *ṛtuvarṇanādhikāra*. The *ṛtuvarṇanādhikāra* is more than twice as long as the similar poem in the *Siddhāntaśiromaṇi*, and more intricate.²²⁹ Here, too, Jñānarāja uses the technique of double entendre; each verse can be read in two ways, one praising a season, the other a deity.²³⁰

²²⁷See 2.3.19.

²²⁸*Siddhāntaśiromaṇi*, *golādhyāya*, *ṛtuvarṇana*.

²²⁹See [52 . 355].

²³⁰The *ṛtuvarṇanādhikāra* of the *Siddhāntasundara* has not been studied here, but much work has been done on it by Christopher Minkowski; these notes are based on his work.

1.3.7 Importance of the *Siddhāntasundara*

In the period of about 350 years between Bhāskara II composing the *Siddhāntaśiromaṇi* in 1150 CE and the composition of the *Siddhāntasundara* around the beginning of the 16th century CE, the Indian astronomers moved in a didactic direction, focusing on writing commentaries on existing treatises, as well as composing *koṣṭhakas*.²³¹ A number of minor *siddhāntas*, namely the *Brahmasiddhānta*, the *Somasiddhānta* and the *Vasiṣṭhasiddhānta*, all of which were discussed above, were composed in this period, but no important *siddhānta* was written.²³² In other words, the *Siddhāntasundara* was the first major *siddhānta* to be written after the influential *Siddhāntaśiromaṇi*.

Jñānarāja and the astronomical tradition

Writing the first major work after some 350 years naturally entails a critical look at and a reassessment of the tradition. This is so in the case of Jñānarāja, and a direct statement as to what shape such a reassessment took in the *Siddhāntasundara* can be found right at the beginning of the text. Jñānarāja says there that what he has written in the *Siddhāntasundara* is the astronomical teachings of Brahman to Nārada, as recorded by the sage Śākalya, with *vāsanās* added. Two significant points regarding Jñānarāja's motivations for writing the *Siddhāntasundara* are raised here:

1. Jñānarāja takes as his main source the somewhat obscure *Brahmasiddhānta*, and
2. his contribution to astronomy is his addition of demonstrations to the science as it is given in the *Brahmasiddhānta*.

The *Brahmasiddhānta*, as well as related texts such as the *Somasiddhānta*, are considered authoritative by Jñānarāja due to their being authored by divine beings and ancient sages. By accepting the *Brahmasiddhānta* as his primary source, Jñānarāja emphasizes, in addition to emphasizing the *Brahmasiddhānta* itself, the fact that it is attributed to a deity. This emphasis is further strengthened when he makes a clear division between the eight divine originators of astronomy and the human beings who subsequently wrote treatises on the topic. The divine works are primary, human works secondary. However, as per the second point above, while Jñānarāja makes no claims to be anything but an ordinary human being, he argues that he is making a contribution, namely adding *vāsanās*.

What all this implies is that Jñānarāja is seeking to bring the *Brahmasiddhānta* and similar treatises into the mainstream of Indian astronomy. As was discussed before, with the exception of the *Sūryasiddhānta*, the eight treatises mentioned by Jñānarāja are somewhat obscure. By composing a treatise emphasizing these texts, in particular the *Brahmasiddhānta*, and providing *vāsanās* and rationales that they are lacking, the texts are drawn into the mainstream of Indian astronomy, to be discussed on the same level as, say, Bhāskara II's *Siddhāntaśiromaṇi*.

²³¹See [74 . 25–26].

²³²See [74 . 26].

Why is Jñānarāja following the *Brahmasiddhānta* in particular? No answer is given in the *Siddhāntasundara*, but we may venture an explanation here. As we will see below on p. 49 regarding the *virodhāparihāra* issue, Jñānarāja is concerned with traditional religious teachings. He is willing to reinterpret passages from sacred texts, but not willing to question their authority. Dikshit notes that the *Brahmasiddhānta* treats the subject of religion, a subject not met with in astronomical texts.²³³ Unfortunately, however, he does not specify this further. No in-depth study of the *Brahmasiddhānta* is available, but it seems likely that this particular text matched Jñānarāja's agenda, or perhaps that Jñānarāja was inspired by its approach.

Primacy of the *golādhyāya*

We established previously that despite many manuscripts placing the *grahagaṇitādhyāya* at the beginning of the *Siddhāntasundara*, the text actually begins with the *golādhyāya*. In earlier *siddhāntas*, such as the *Śiṣyadhīvrddhidatantra*, the *Vaṭeśvarasiddhānta*, and the *Siddhāntaśiromaṇi*, the *gola* section is placed at the end of the work.²³⁴ In addition, the authors of these works found it necessary to preface their *gola* sections with arguments for why this section is to be studied.²³⁵

In contrast, Jñānarāja does not find it necessary to justify his *golādhyāya*, he simply begins with it. Importance was put on the *gola* material by all the great Indian astronomers, but to Jñānarāja it was central: a study of astronomy commenced with a study of the *golādhyāya*. This, of course, aided his endeavor to add *vāsanās* to the material in the *gaṇitādhyāya*, and also gave his readers the theoretical understanding necessary to engage with questions such as that of *virodhāparihāra*.

The issue of *virodhāparihāra*

By *virodhāparihāra* (literally, removal of contradiction) is meant the endeavor to create a synthesis between the cosmology of the *purāṇas* on the one hand, and the cosmology of the astronomical tradition on the other. The astronomers' approach to the inconsistencies between the two cosmologies was to incorporate compatible elements into their own system, while rejecting contradictory elements. Thus, as noted, Meru found its place on the north pole of the spherical Earth and the annular oceans and continents were placed on the southern hemisphere, while notions such as the Earth being flat and the Sun being closer than the Moon were rejected.

The approach changed with Jñānarāja. Rather than accepting certain elements and rejecting others, Jñānarāja considered the *purāṇas* authoritative and sought to create a synthesis in which both cosmologies could be true. This entailed reinterpreting ideas from both traditions, but never rejecting any elements from the *purāṇas*.²³⁶

²³³See [22 . 2.49].

²³⁴At least this is how the printed editions organize the texts (see [11], [94], and [87]).

²³⁵See, e.g., *Śiṣyadhīvrddhidatantra* 24.2–6, *Vaṭeśvarasiddhānta* (*gola*) 1.1–5, and *Siddhāntaśiromaṇi* (*golādhyāya*) 1.2–5.

²³⁶See [52].

1.4 The manuscripts of the *Siddhāntasundara*

Photocopies of twenty manuscripts were made available to me by Pingree for the preparation of the critical edition of the *Siddhāntasundara*. The structure of the following descriptions of the manuscripts conforms to the format used in Pingree's catalogue of the Sanskrit astronomical manuscripts in the Maharaja Man Singh II Museum in Jaipur.²³⁷

The manuscript descriptions mention certain features peculiar to the manuscript in question, but this is not to imply that they occur consistently in the given manuscript, only that they occur. A folio (or page) number in angle brackets means that this is the appropriate number, but the particular folio (or page) was not numbered by the scribe. If there are two folia (or pages) with the same number, say 29, the notation 29_a and 29_b is used. If a manuscript has two parts, α and β will be used to distinguish them.

1.4.1 Description of the available manuscripts

A — Ānandāśrama 4350

Catalogue description: not available to me.²³⁸

Two parts, α and β . α : 47 pages, paginated <1>, 2–17, 20–49 (pp. 18–19 missing in the photocopy). β : 32 pages, paginated <1>, 2–32. 21 cm by 16 cm (based on photocopy, so uncertain). 16 lines per page. Devanāgarī script. α is dated *mandavāsara*, *tithi* 13 of the dark *pakṣa* of *jyaiṣṭha*, *śaka* 1810 = Saturday, July 7, 1888 CE. β is dated *budhavāsara*, *tithi* 11 of the dark *pakṣa* of *jyaiṣṭha*, *śaka* 1810 = Wednesday, July 4, 1888 CE. Incomplete (due to two missing pages in α): α contains the *grahaganitādhyāya*, and β the *golādhyāya*. In the photocopy, α comes first, but β was copied before α by the scribe. I am unable to determine whether or not the two parts are in the right order in the photocopy.

From the photocopy available to me, it appears that the manuscript was organized as a European book. It is paginated rather than foliated, the page numbers being placed at the center of the page above the text.

The manuscript contains many errors and has been of limited use. It should be noted, though, that this is the manuscript used by Dikshit for his notes on the *Siddhāntasundara* in his *Bharatiya Jyotish Sastra*.²³⁹

B₁ — Bhandarkar Oriental Research Institute 283 of Viśrāma (i)

Catalogue description: [58. 350–351, no. 1240].

²³⁷See [78].

²³⁸The manuscript is listed by Pingree in [65. A.3.75] with reference to a handwritten list of the manuscripts in the Ānandāśrama, Poona, in possession of V. Raghavan (see [65. A.1.26, under Ānandāśrama]). Unfortunately, I was unable to locate this in the collection of the late David Pingree, and have not been able to find it elsewhere either.

²³⁹See [22].

39 leaves, foliated <1>, 2, <3>, 4–10, <11>, 12, <13>, 14, <15>, 16, <17>, 18, <19>, 20, <21>, 22, <23>, 24, <25>, 26, <27>, 28, <29>, 30, <31>, 32, <33>, 34–35, <36>, 37–38, <39>. 11½ by 33½ cm. 8–9 lines per page. Some marginalia. Devanāgarī script. Complete: begins with the *grahagaṇitādhyāya* and ends with the *golādhyāya*.

The leaves are foliated in the top left corner and the bottom right corner of the recto. F. 32 was originally foliated 31; a correction is made in the lower right corner, but not in the upper left corner. F. <39> is blank except for title of the work. The manuscript catalogue states that the manuscript consists of 38 leaves, presumably discounting f. <39>.

The manuscript catalogue provides the following additional information: modern paper with watermarks, borders ruled in double red lines, and yellow pigment and white chalk used for corrections. The manuscript is further described as “modern” in the catalogue.

B₂ — Bhandarkar Oriental Research Institute 219 of A 1882–83

Catalogue description: [58. 349–350, no. 1239].

19 leaves, foliated 1, <2–5>, 6–7, <8>, 9, <10>, 11–14, <15>, 16–19 in the lower-right corners, as well 25–29, <30>, 31, <32–37>, 38–41, <42>, 43 in the upper-left corners. 27½ by 12½ cm. 10–13 lines per page. Marginalia. Devanāgarī script. Not dated. The manuscript belonged to Rāmākṛṣṇa Jyotirvid. Complete: contains the *golādhyāya*.

The manuscript catalogue notes that the handwriting is somewhat careless but legible and uniform. While this is correct, the photocopying process has made much of the text hard to read, especially the marginalia, parts of which are unreadable. In addition, some folia are torn and have damage to the text. Other additional information noted in the manuscript catalogue: country paper, appears to be fairly old, borders ruled in double black lines, red pigment used for marking verse number and colophons, yellow pigment used for corrections, and edges extremely worn and moth-eaten.

A list of chapters of the work and the folia on which they commence is given on f. 19v (according to the first numbering given above). The list begins with the 11 chapters of the *grahagaṇitādhyāya*, which is called *pūrvārdha*, “initial half”, beginning on a folio 1; the *golādhyāya*, which is called *uttarārdha*, “latter half”, follows beginning on a folio 25. In other words, the list of chapters follows the second numbering. However, it is not clear which of the two numberings is original, nor whether the *grahagaṇitādhyāya* part referred to in the index was originally part of the manuscript. In the critical apparatus, folio references are to the first numbering.

Peculiarities of B₂ include writing simply त्व instead of त्व (in the word तत्त्व). Furthermore, त्छ is written instead of both त्थ and च्छ.

B₃ — Bhandarkar Oriental Research Institute 880 of 1884–87

Catalogue description: [58. 352, no. 1242].

20 leaves, foliated 1–20. 27½ by 12½ cm. 9–10 lines per page. Marginalia. Devanāgarī script. Not dated (but see below and note that R₂ is dated). Complete: contains the *golādhyāya*.

F. 1r is not extant in the photocopy; it is presumably blank. The marginalia consist of occasional variant readings and other annotations added by a second hand. Additional remarks made in the manuscript catalogue: thick country paper, not very old in appearance, borders ruled in double red lines and edges in single, red pigment used for marking verse numbers and colophons, and yellow pigment and white chalk used for corrections.

The three manuscripts B₃, B₄, and R₂ were copied by the same scribe, and the annotations in each are made by the same second hand. It is certain that B₄ and R₂ really are two parts of the same manuscript, for R₂ commences precisely where B₄ breaks off. Considering that B₃ is in the same hand and has marginalia by the same second hand, it is highly likely that B₃ is part of the same manuscript, consisting of the *golādhya*, while B₄ and R₂ together contain the *grahagaṇitādhya*. A difference between B₃ on the one hand, and B₄ and R₂ on the other, should be noted, though. In B₃, the chapter colophons are written right after the concluding verse of each chapter by the scribe himself, but the scribe did not include chapter colophons in B₄ and R₂, where they were added in the margin by the second hand. The abbreviated title given in the top-left margins is *si-ṣuṃ-go* (or minor variations thereof). That the abbreviated title in the top-left margins of B₄ and R₂ is *si-ṣuṃ-pū* (or minor variations thereof) indicates that the *grahagaṇitādhya* was considered the first part (*pūrvārdha*, initial half) of the work.

Peculiarities of B₃ include writing simply त्व instead of त्व (in the word तत्त्व).

B₄ — Bhandarkar Oriental Research Institute 881 of 1884–87

Catalogue description: [58.351, no. 1241].

8 leaves, foliated 1–8. 27½ by 12 cm. 9 lines per page. Marginalia. Devanāgarī script. Not dated (but see below and note that R₂ is dated). Incomplete: starts from the beginning of the *grahagaṇitādhya* (verse 2.1.1), and ends in verse 2.2.3 (extant part of the verse: *āśāṃka*).

F. 1r is not extant in the photocopy; it is presumably blank. The marginalia consists of occasional variant readings and other annotations (including chapter colophons) added by a second hand. Additional remarks made in the manuscript catalogue: country paper, not very old, borders ruled in double red lines and edges in single, red pigment used for marking verse numbers, and yellow pigment and white chalk used for corrections.

B₄ and R₂ are parts of the same manuscript. For more details, see the description of B₃.

Peculiarities of B₄ include writing simply त्व instead of त्व (in the word तत्त्व), and there is no distinction between ऋ and ॠ, which are both written ऋ. Sometimes द्यु is written द्य (as in हद्यु instead of हॠद्यु).

B₅ — Bhandarkar Oriental Research Institute 860 of 1887–91

Catalogue description: [58.352–353, no. 1243].

27 leaves, foliated <1>, 2, 3_a, 3–8, <9>, 10–25, <26>. 8½ cm by 28½. 7–10 lines per page. Devanāgarī script. Dated śaka 1686 = 1764 CE or 1765 CE. Complete: contains the *grahagaṇitādhya*.

F. <26>v is not extant in the photocopy; it is presumably blank. Ff. 2, 3_a are by a different hand, added to replace a missing leaf (the manuscript catalogue notes that in addition to the handwriting, the paper is different as well). The photocopy is quite dark and often hard to read. Additional remarks made in the manuscript catalogue: country paper, old in appearance, borders not ruled, red pigment used for marking colophons, and edges of the leaves worn out.

Peculiarities of B₅ include writing simply त्व instead of त्व, स्त्र for स्थ, द instead of द, छ for च्छ, ष for both ष and ष, द for द, त्र for both त्र, and स्त्र for स्थ.

I — India Office Library 2114b

Catalogue description: [30 . 1.5.1029, no. 2902].

37 leaves, foliated 1–37. 11½ cm by 24 cm. 6–13 lines per page. Devanāgarī script. Dated *bhauma-vāsara*, 5 *kr̥ṣṇapakṣa* of *śrāvaṇa* in *saṃvat* 1839 = Tuesday, September 27, 1782 CE. Complete: contains the *grahagaṇitādhyaṇya*.

F. 1r not extant in the photocopy. The original folio numbers, generally placed in the top left corners of the versos of the leaves, are not extant on all leaves. However, another hand has added the numbers in the top right corner in Arabic numerals, including the leaves where the original number is visible. The manuscript was copied by several hands according to the manuscript catalogue, but it is difficult to determine where one scribe takes over from another in the photocopy.

Peculiarities of I include writing स्त्र for स्थ, द instead of द, द for द, छ for च्छ, ष for both ष and ष, त्र for त्र, धृ for द, घ्री for गघ्री, and स्त्र for स्थ.

L — British Museum Add. 14,365p

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Catalogue description: [4 . 187, no. 452].

28 leaves, foliated 1–27, <28>. 21 by 12½ cm.²⁴⁰ 13 lines per page. Devanāgarī script. Not dated. Complete: contains the *grahagaṇitādhyaṇya* and the *golādhyaṇya* (in that order).

F. <28>v is not extant in the photocopy; presumably it is blank. Ff. 26v, 27r were copied poorly and are nearly illegible. The manuscript does not appear to be very old.

M₁ — Asiatic Society of Bombay 289

Catalogue description: [102 . 1.4.94, no. 289].

15 leaves, foliated 1–13, <14>, 15. 38 by 23½ cm. 19–22 lines per page. Devanāgarī script. Not dated. Complete: contains the *grahagaṇitādhyaṇya* and the *golādhyaṇya* (in that order).

Due to an error in the copying process, most of the text on ff. <14>v, 15r, 15v does not appear in the photocopy. The manuscript does not appear to be very old.

Peculiarities of M₁ include writing त्व for त्व, त्र for द, द instead of द, द for द, छ for च्छ, ष for both ष and ष, त्र for त्र, धृ for द, and घ्री for गघ्री.

²⁴⁰This information is not given in the manuscript catalogue, and the dimensions given are those of the photocopy.

M₂ — Asiatic Society of Bombay 290

Catalogue description: [102 . 1.4.94, no. 290].

20 leaves, foliated 1–7, <8–10>, 11, <12–16>, 17–20. 17 lines per page. Devanāgarī script. Not dated. Complete: contains the *grahagaṇitādhyāya* and the *golādhyāya* (in that order).

The manuscript does not appear to be very old.

Peculiarities of M₂ include writing त्व for त्व, त्थ for द्ध, द्ध instead of द्ध, द्ध for द्ध, छ for च्छ, द्ध for both द्ध and द्ध, धृ for द्ध, स्थ for स्थ, and घ्री for ग्री.

M₃ — Asiatic Society of Bombay 291

Catalogue description: [102 . 1.4.94–95, no. 290].

53 leaves, foliated 1–32, <32_a>, 33_a, 33–50, <51>. 31½ by 11 cm. 10–13 lines per page. Devanāgarī script. Not dated (manuscript incomplete). The manuscript contains the *Grahagaṇitacintāmaṇi*, Cintāmaṇi's commentary on the *Siddhāntasundara*, in addition to the text of the *Siddhāntasundara*. Incomplete: contains the text and commentary on the *madhyamādhikāra* and part of the *spṣṭādhikāra*, ending in the commentary on verse 2.2.34 (numbered 35 in the manuscript).

Ff. 1r, <51>v are not extant in the photocopy; they are presumably blank. F. <51>r ends abruptly halfway into the first line. F. <32_a> has only four lines on one page, and the other page is blank. It is not clear to me at present whether this leaf, though clearly in the same hand as the rest, belongs here. F. 33_a and f. 33 commence at the same place in the text, but f. 33 contains four syllables more of the text than f. 33_a. For this reason, it is f. 33 that connects with f. 34. For the edition, f. 33 has been used, and not f. 33_a.

Peculiarities of M₃ include writing त्व for त्व, ति for त्ति, द्ध instead of द्ध, छ for च्छ, द्ध for both द्ध and द्ध, धृ for द्ध, and स्थ for स्थ.

O — Oxford d. 805(5)

Catalogue description: [75 . 8, no. 21].

18 leaves, foliated <1>, 2–18. 11½ by 26 cm. 7–12 lines per page. Devanāgarī script. Not dated (manuscript incomplete). Incomplete: starts at the beginning of the *golādhyāya* and ends in verse 26 of the *ṛtuvarṇanādhikāra* (extant part of the verse: *yanmitrasya karapratāpanihatās tū*).

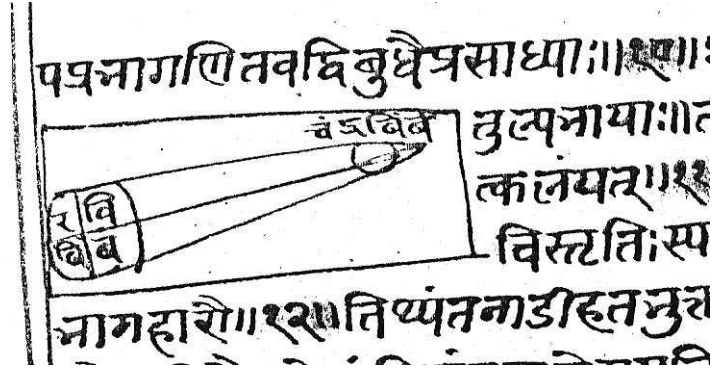
Ff. 14–18 were originally foliated 12–16, but corrected to 14–18.

Peculiarities of O include writing त्व for त्व, छ for त्थ, द्ध for द्ध, छ for च्छ, द्ध for both द्ध and द्ध, धृ for द्ध, and स्थ for स्थ. At times ऊ is used for उ.

R₁ — Rajasthan Oriental Research Institute (Kota) 981

Catalogue description: [99 . 484–485, no. 4306].

111 pages, paginated 1–45, 46_a, 46_b, 47–110. 12 cm by 26 cm. 9 lines per page. Copied by Travāḍibhaṭṭa Prāṇajīvaṇa in Koṭhāsyaṅrāma (?). Dated *bhṛguvāsara*, *tithi* 10 of the dark *pakṣa* of *māgha*, *saṃvat* 1834 = Friday, February 20, 1778 CE. Complete: begins with the *golādhyāya* (which

Figure 1.1: Figure on p. 84 in R₁

is called *pūrvārdha*, “initial half”) and ends with the *grahagaṇitādhyaṃya* (which is not named, but called *uttarārdha*, “latter half”).

Most of the foliation numbers are not present on the photocopy due to the left and right borders being truncated in the copying process, and those which are still visible are partially destroyed. The page numbers given above are in Arabic numerals in the hand of Pingree. According to the catalogue description, there are 57 leaves, meaning that 3 (presumably blank) pages are not included in the photocopy. P. 110 is placed at the beginning of the photocopy. There is a figure on p. 84, which illustrates verse 2.5.10. A scan of the figure is given in Figure 1.1. The manuscript contains numerous errors, but also meaningful readings not found elsewhere.

Peculiarities of R₁ include writing त्व for त्व, छ for त्थ, छ for क्ष, य for द्य, छ for च्छ, ग्री for ग्री, द्र for द्व, गो for ग्गो, दृ for दृ, ष for both ष and ष, and स्छ for स्थ.

R₂ — Rajasthan Oriental Research Institute 4733

Catalogue description: [44. 310–311, no. 5535].

23 leaves, foliated 9–31. 27½ by 12 cm. 9 lines per page. Marginalia. Copied by Brāhmaṇa Harisuṣa (i.e., Harisukha). Dated *somavāsara*, *tithi* 10 of the bright *pakṣa* of *āśvina*, *saṃvat* 1843/*śaka* 1708 (year given as current year) = Monday, October 2, 1786 CE. Incomplete: begins in verse 2.2.3 (from *bhuva* in *pāda* a) and ends at the end of the *grahagaṇitādhyaṃya*.

The marginalia consists of occasional variant readings and other annotations (including chapter colophons) added by a second hand. F. 31v contains only two verses cited from the *Siddhāntasārvabhauma*.²⁴¹

There is one figure in the manuscript. It is on f. 9v by the right margin beneath the text. It illustrates the explanation of the Sines in 2.2.6–9 (the text visible in Figure 1.2 belongs to verse 2.2.9). There is a figure on f. 9v, which illustrates verses 2.2.6–9. A scan of the figure is given in Figure 1.2.

²⁴¹ *Siddhāntasārvabhauma* 1.143–144 (see [98. 1.115]).

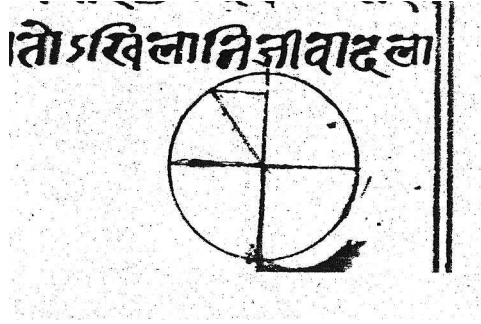


Figure 1.2: Figure on f. 9v in R₂

B₄ and R₂ are parts of the same manuscript. For more details, see the description of B₃.

Peculiarities of R₂ include writing त्व for त्व, छ for च्छ, ष्ट for both ष्ट and ष, and घ्री for ग्वी. Furthermore, ढ and इ are indistinguishable in this manuscript.

R₃ — Rajasthan Oriental Research Institute (Jodhpur) 37247

Catalogue description: [92 . 344–345, no. 3079].

Two parts, α and β . α : 15 leaves, foliated 1–15. β : 24 leaves, foliated 1–24. 26 cm by 12 $\frac{1}{2}$ cm. 12 lines per page. α is dated *somavāsara*, *tithi* 14 of the dark half of *āṣāḍha*,²⁴² *saṃvat* 1843 = Monday, July 24, 1786 CE. β is dated *bhṛguvāsara*, *tithi* 8 of the bright half of *bhādrapada*, *saṃvat* 1843/*śaka* 1708 (year given as current year) = Friday, September 1, 1786 CE. Complete: α contains the *golādhya* and β the *grahagaṇitādhya*.

The photocopy made available to me by Pingree is organized into two parts. The first, labeled “RORI (Jodhpur) 37247 Siddhāntasundara of Jñānarāja pt. I” (with “RORI (Jodhpur) 37733” written but crossed out beneath “RORI (Jodhpur) 37247”) by Pingree, consists of β ff. 1v–16r, and the second, labeled “RORI (Jodhpur) 37247 Siddhāntasundara of Jñānarāja pt. II” by Pingree, consists of α ff. 1v–15r followed by β ff. 16v–24r. Since β f. 16r and β f. 16v are separated in the photocopy, the misplacement of part of β cannot be explained by a disarrangement of leaves in the original manuscript, but must be due to a misplacement of pages in the photocopy.

According to the catalogue description, the manuscript has 24 leaves, indicating that only the leaves of β are included. α f. 1r, β f. 1r, and β f. 24v not extant in the photocopy.

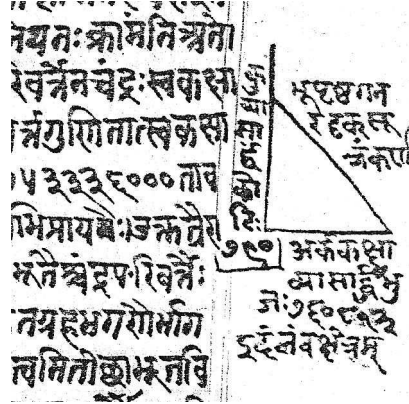
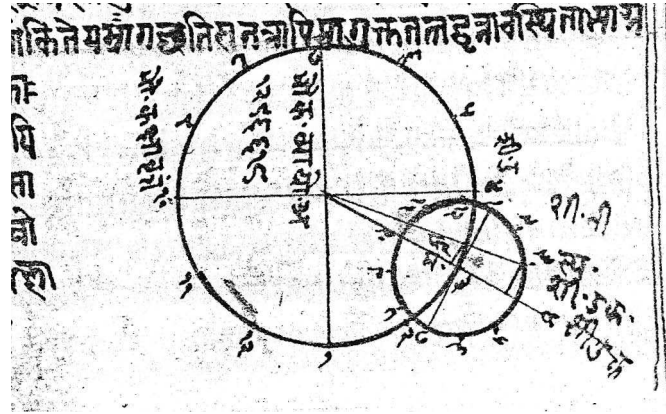
Peculiarities of R₃ include writing त्व for त्व, छ for च्छ, ष्ट for both ष्ट and ष, and घ्री for ग्वी.

V₁ — Benares 35318

Catalogue description: [60 . 96–97, no. 35318].

67 leaves, foliated 12–78. 28 $\frac{1}{2}$ by 12 $\frac{1}{2}$ cm. 12 lines per page. Some marginalia. Devanāgarī script. Not dated (manuscript incomplete). The manuscript contains the *Grahagaṇitacintāmaṇi*,

²⁴²Possibly this is to be read as *tithi* 4, but this does not work so well with the weekday given.

Figure 1.3: Figure on f. 39v in V₁Figure 1.4: Figure on f. 68v in V₁

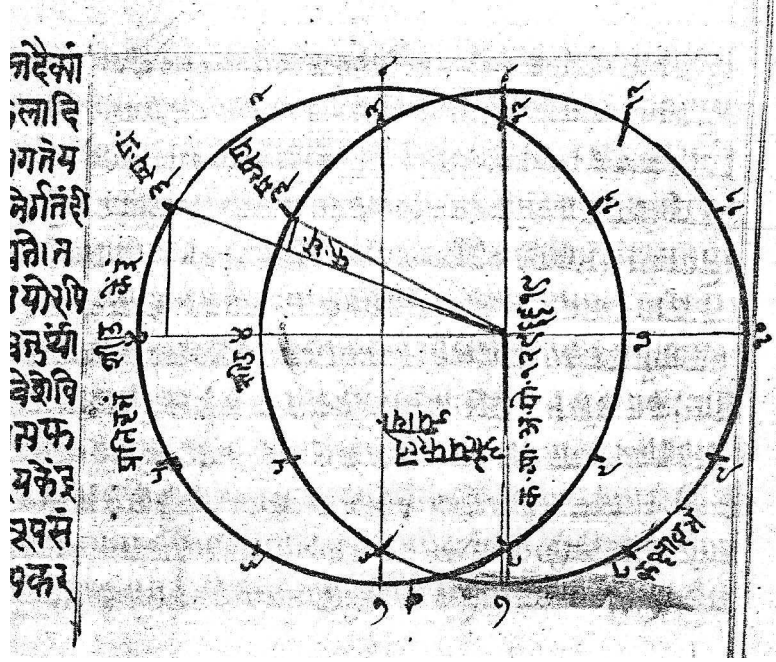
Cintāmaṇi's commentary on the *Siddhāntasundara*, in addition to the text of the *Siddhāntasundara*. Incomplete: begins in the commentary on 1.1.19 and ends in the commentary on 1.4.7.

There are three figures in the manuscript, on f. 39v, f. 68v, and f. 71r, respectively. The first, belonging to the commentary on 1.1.72, is shown in Figure 1.3; the second, belonging to the commentary on 1.3.5, is shown in Figure 1.4; and the third, belonging to the commentary on 1.3.11–13, is shown in Figure 1.5.

As figures are rare and recent, the manuscript is probably not that old; the handwriting also point towards the manuscript not being very old, probably from the 19th century.

V₂ — Benares 35566

Catalogue description: [60 . 120–121, no. 35566].

Figure 1.5: Figure on f. 71r in V₁

73 leaves, foliated 1–41, 43–74.²⁴³ 20 by 11½ cm. 9–11 lines per page. Some marginalia. Devanāgarī script. Not dated. Incomplete (due to a missing leaf): contains the *golādhya* and the *grahaganitādhya* (in that order); f 41v ends with 2.1.85 and f. 43r begins in 2.2.6.

Peculiarities of V₂ include writing त्व for त्व, स्थ for स्थ, त्छ for त्थ, त्थ for द्व, द्य instead of ह्य, द्व for द्व, छ for च्छ, ष for both ष and ष, त्छ for त्थ, धृ for दृ, and घ्री for गघ्री. The manuscript has occasional *prṣṭhamātrās*.²⁴⁴

V₃ — Benares 35627

Catalogue description: [60.124–125, no. 35627].

22 leaves, foliated 1–4, 6–7, 11–14, 16–27. 26 by 12 cm. 10–14 lines per page. Devanāgarī script. Dated *saṃvat* 1845 = 1788 CE or 1789 CE. Incomplete: contains a partial (due to missing leaves) *grahaganitādhya*.

Peculiarities of V₂ include writing त्व for त्व, क्षे for त्क्षे (in the word तत्क्षेप), स्थ for स्थ, त for त्त, त्छ for त्थ, द्य for ह्य, ष for both ष and ष, छ for च्छ, and त्छ for त्थ. There are a few occurrences of

²⁴³The manuscript catalogue does not indicate that f. 42 is missing; it is not, however, found in my copy.

²⁴⁴A *prṣṭhamātrā* is the use of the vertical stroke ८, normally used to indicate a long a-vowel (*ā*), to substitute for a diagonal diphthong-stroke above the line. For example, कुरुक्षेत्र for कुरुक्षेत्र (no misreading possible because रु is not meaningful as a unit by itself) or सिद्धान्तसुन्दार for सिद्धान्तसुन्दरे (later scribes might misread this as *siddhāntasundāra* instead of the correct *siddhāntasundare*), शरागराम for शरगोराम (later scribes might misread this as *śarāgarāma* instead of the correct *śaragorāma*), and आरासौरि for आरसौरि (later scribes might misread this as *ārāsori* instead of the correct *ārasauri*). Such *prṣṭhamātrās* are mainly confined to older manuscripts, but can occur in more recent manuscripts as well.

prṣṭhamātrās.

V₄ — Benares 36902

Catalogue description: [60 . 242–243, no. 36902].

36 leaves, foliated 1–36. 27½ by 14 cm. 7 lines per page. Devanāgarī script. Not dated. Complete: contains the *grahagaṇitādhyaṃya*.

F. 1r is not extant in the photocopy; presumably it is blank.

Peculiarities of V₄ include writing त्व for त्व, ष for both ष and ष, छ for च्छ, and द् for द्. The scribe consistently uses proper nasals rather than *anusvāras*.

V₅ — Benares 36907

Catalogue description: [60 . 242–243, no. 36907].

24 leaves, foliated 1–24. 24½ by 10½ cm. 15 lines per page. Copied by Lāla Candra in Rābhanaṅgara (?). Dated *bhaumavāsara*, *tithi* 10 of the dark *pakṣa* of *mārgaśīrṣa*, *saṃvat* 1721/*śaka* 1586 (current year, not expired year) = Tuesday, December 25, 1663 CE (Julian date: December 15, 1663 CE). Complete: contains the *golādhyaṃya* and the *grahagaṇitādhyaṃya* (in that order), but the order of the sections is unusual.²⁴⁵

F. 24v not extant in the photocopy; presumably it is blank, as the text ends on f. 24r.

The manuscript has been worked over by a second hand working with another manuscript as well. Using rounded brackets, the second hand has marked passages that are not found in his other manuscript and inserted passages from it not found in V₅ in the margins. The other manuscript used by the second hand appears to be very similar to I, although there are variants recorded that are not found in I.²⁴⁶

Peculiarities of V₅ include writing त्व for त्व, ध for द्, य for द्य, त्छ for त्थ, स्छ for स्थ, ष for both ष and ष, छ for च्छ, and द् for द्. The scribe has the peculiar habit of writing an *ā*-vowel that does not fit at the end of a line as a र at the beginning of the next line. Similarly, a *visarga* that does not fit at the end of a line is written at the beginning of the next line. Furthermore, *prṣṭhamātrās* are frequently used (see fn. 244 on p. 58).

1.4.2 Stemma

A *stemma* is a family tree showing the relationship between the available manuscripts. It is based on the principle that sharing of common readings implies a common origin. In other words, if two manuscripts share a sufficient number of common readings, we may assume that they both derive from a common source. We will not enter a detailed discussion of stemmatics here, but the construction of a stemma is nevertheless desirable for the assessment of the available manuscripts of the *Siddhāntasundara*.

²⁴⁵The structure of V₅ was discussed above (see p. 35).

²⁴⁶See, for example, the variant reading noted in the margin for 2.1.86^a.

Let us begin by recapitulating the distribution of manuscripts. For the edition of the *golādhya*, altogether 13 manuscripts were available: (1) A, (2) B₁, (3) B₂, (4) B₃, (5) L, (6) M₁, (7) M₂, (8) O, (9) R₁, (10) R₃, (11) V₁, (12) V₂, and (13) V₅. For the edition of the *grahagaṇitādhya*, altogether 16 manuscripts were available: (1) A, (2) B₁, (3) B₄, (4) B₅, (5) I, (6) L, (7) M₁, (8) M₂, (9) M₃, (10) R₁, (11) R₂, (12) R₃, (13) V₂, (14) V₃, (15) V₄, and (16) V₅.

From the distribution of manuscripts, it is clear that it is necessary to present separate stemmata for the *golādhya* and the *grahagaṇitādhya*. Since only one section from the *golādhya* has been edited, but six from the *grahagaṇitādhya*, we will start the discussion with the *grahagaṇitādhya*.

Stemma for the *grahagaṇitādhya*

A clearly distinct group is formed by B₁, L, M₁, and M₂. For one thing, they stand apart in that they have 12 rather than 11 sections in the *grahagaṇitādhya*. In addition, they share readings and lacunae to such an extent that a close relationship between them is certain. Of the four manuscripts, B₁ and M₁ follow each other closely, and the same is true of L and M₂; however, based on lacunae in the manuscripts, the only possibility for a direct copying is that L is a copy of M₂, though whether this is indeed the case cannot be established with certainty.

Related to this group is A. While A has 11 sections in the *grahagaṇitādhya* and has variant readings differing from B₁, L, M₁, and M₂, other traits are shared, such as a structure commencing with the *grahagaṇitādhya*. All five manuscripts are recent and very legible.

Another distinct group is formed by B₄, R₂, and R₃. It was noted in the manuscript descriptions that that B₄ and R₂ are two parts of the same manuscript, and that B₃ forms the *golādhya* part of it. For that reason, we will use the symbol B* to denote these as one manuscript.²⁴⁷ Similarities establish clearly that B* and R₃ are related. In fact, it is likely, though I cannot establish this with certainty, that either B* is a copy of R₃, or they are both copies of the same manuscript.

A third group, though more loosely connected, consists of I, V₂, and V₄. These three manuscripts share certain characteristics that set them apart from the rest, including shared readings, order of verses in the text, and so on.

The remaining manuscripts are hard to group together. In a general grouping, they belong with the B₁-L-M₁-M₂ and B*-R₃ groups, but establishing a closer relationship has not been possible. R₁ has some unique characteristics, such as the ordering of some verses in the *tripraśnādhikāra*, but not enough to set it fully aside from the B*-R₃ group.

The stemma for the *grahagaṇitādhya* manuscripts is shown in Figure 1.6. The original copy of the *Siddhāntasundara* is given as α .²⁴⁸ From α come two main branches, β and γ . To γ belong I, V₂, and V₄. As can be seen in the stemma, while all three manuscripts descend from γ , the exact relationship between them is unclear. The remaining manuscripts all find their place on the β branch. Between β and A and B₁-L-M₁-M₂ and B*-R₃ is inserted δ in order to show that these

²⁴⁷This convention will only be followed here; in the critical apparatus, B₃, B₄, and R₂ will be used.

²⁴⁸Note that it is not certain that there was one original manuscript of the text. It is entirely possible that Jñānarāja revised a first text, and that different versions were circulating.

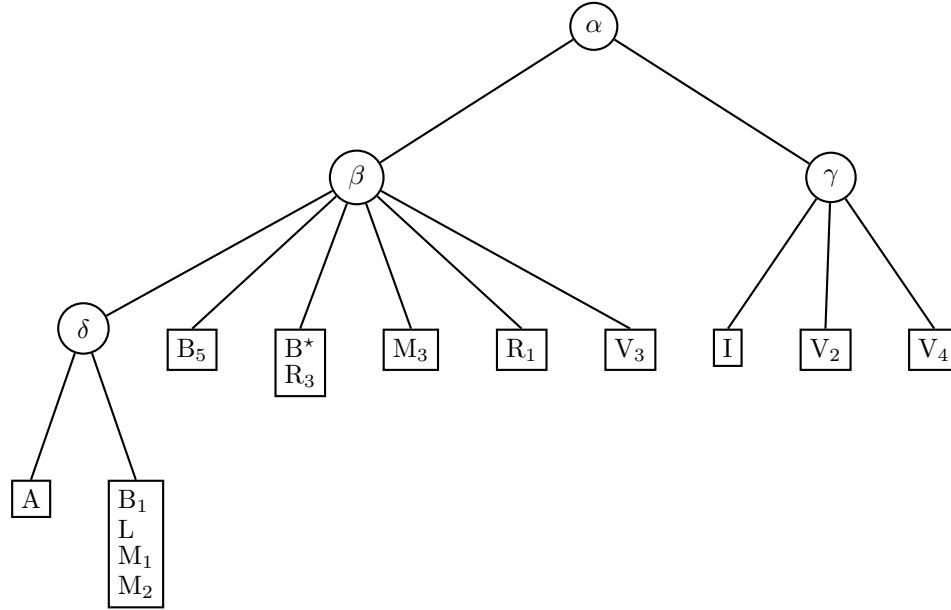


Figure 1.6: Stemma for the manuscripts containing the *grahagaṇitādhyaṃya*

two groups derive from a common source. The remainder of the manuscripts belong more generally to β . B^* and R_3 are grouped together due to the close relationship described.

Note that M_3 is included in the stemma. This manuscript contains Cīntāmaṇi's commentary, which makes it unique in the group, but when it comes to the text of the *Siddhāntasundara* itself, M_3 groups with the remaining manuscripts in this way.

Not included in the stemma is V_5 . V_5 is structurally different from all the other manuscripts, and thus very difficult to place in the stemma. However, when it comes to readings and ordering of verses, V_5 lines up with the β branch. The manuscript which a second scribe used when annotating V_5 , on the other hand, belongs to the γ branch, and is most similar to, though not identical with, I .

Stemma for the *golādhyaṃya*

The situation for the *golādhyaṃya* is more complicated. As before, A and B_1 - L - M_1 - M_2 , on the one hand, and B^* - R_3 , on the other, group together. However, no clear pattern emerges when it comes to the remaining manuscripts.

The stemma for the manuscripts of the *golādhyaṃya* is shown in Figure 1.7. The β and γ branches are maintained here based on the evidence from the *grahagaṇitādhyaṃya*; there is nothing in the evidence from the *golādhyaṃya* alone that justifies separating V_2 from the rest of the manuscripts. Similarly, O is arbitrarily placed in the β group; there is no evidence to the effect that it does not belong in the γ group.

As such, the stemma for the *golādhyaṃya* is not satisfactory. It is hoped that when I finish editing the entire *Siddhāntasundara* this difficulty will be solved.

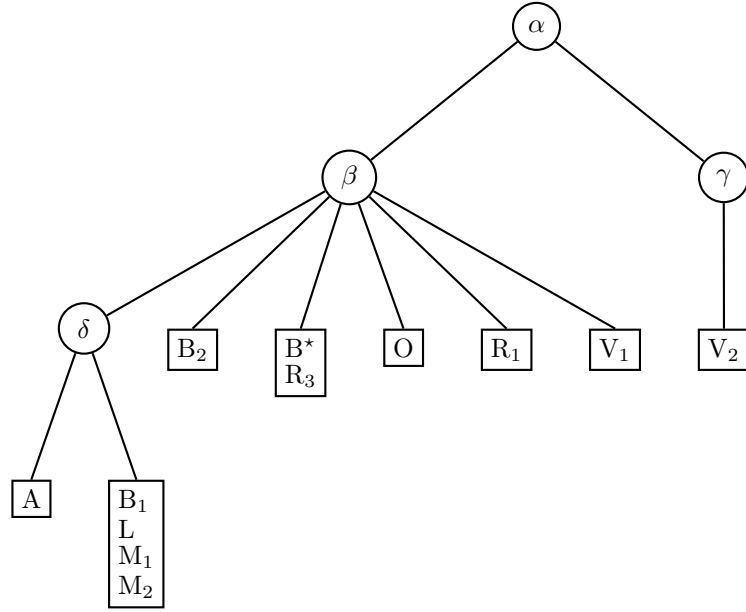


Figure 1.7: Stemma for the manuscripts containing the *golādhyāya*

Note also that as in the case of the *grahagaṇitādhyāya*, V_1 , which contains Cintāmaṇi's commentary, is included in the stemma. Placing this manuscript in the β group is based on M_3 's connection with that group in the case of the *grahagaṇitādhyāya*; however, more evidence is needed before it can be placed there firmly. As before, V_5 , which is structurally different from the other manuscripts, is not included in the stemma.

Manuscripts used for the critical edition

Due to the clear relationship between B_1 , L , M_1 , and M_2 , it was felt unnecessary to incorporate all of these manuscripts for the edition. As such, only M_1 and M_2 were used. In addition to B_1 and L , A , which is a recent and unreliable manuscript that shares similarities with the B_1 - L - M_1 - M_2 group, was not utilized for the edition. Besides these, however, all other manuscripts were used. Thus for the *golādhyāya*, B_2 , B_3 , M_1 , M_2 , O , R_1 , R_3 , V_1 , V_2 , and V_5 were utilized. For the *grahagaṇitādhyāya*, B_4 , B_5 , I , M_1 , M_2 , M_3 , R_1 , R_2 , R_3 , V_2 , V_3 , V_4 , and V_5 were used.

1.4.3 Structure of the edited text and the critical apparatus

The sole exception to the verse format of the *Siddhāntasundara* is a few passages in the *tripraśnādhikāra*.²⁴⁹ In the text of the *Siddhāntasundara* established in this edition, each verse is given in four lines with one *pāda* (a quarter of a verse) on each of the lines. Every line has a number, but only every fifth line is numbered in the margin.

²⁴⁹These prose passages provide solutions for the problems given in that section.

Page changes in the manuscripts

In order that the reader will be able to know on which page of any of the manuscripts a given passage is found, page changes in the manuscripts are noted in the edition. A “|” is used in the text to indicate a place where there is a page change in one or more manuscript with further details being given in the margin. If more than one manuscript has a page change in the same line, the first marker corresponds to the manuscript mentioned first, and so on. To give an example, in the established text, 2.2.17^c reads

भौमा|चञ्चलनीचतुङ्गवलये भा|गाः शराग्न्यश्विनो २३५ ।

and “f. 4r M₁, p. 64 R₁” is given in the margin. This means that in M₁, f. 3v ends with भौमा and f. 4r begins with चञ्चल. Similarly, in R₁, p. 63 ends with वलये भा and p. 64 begins with गाः.

In the case of 2.1.31^a, which in the established text reads

मध्या भुक्तिः स्यादलं स्पष्ट|तस्त -

the “f. 3r R₃ & f. 35r V₂” in the margin indicates that a page change occurs at the place of the “|” in both R₃ and V₂.

Some manuscripts have two parts, called α and β in the descriptions, one containing the *golā-dhyāya* and the other the *grahaganitādhyaṃya*. Since no confusion arises from omitting the α or the β in the margin when a page change in the manuscript in question occurs, such omissions are made consistently. Similarly, when a leaf of a manuscript has no foliation number, the angle brackets used to indicate this in the description of the manuscript have been omitted in the marginal notes indicating page changes. This is done due to space constraints in the margins.

In 2.2.25^d, which reads

ज्जा|तं मन्दफलं भवेत्स्फुटमलं किं चित्रमत्र क्रमे ॥ २५ ॥

the “f. 11r b V₃” in the margin means that in V₃, f. 11r begins with तं मन्दफलं after a break in the manuscript, i.e., the “b” (for break) indicates that f. 10 is not extant in V₃ (in fact, ff. 8–10 are missing). Similarly, “f. 11v e V₃” (where the “e” is for end) would have meant that f. 11v ends here, and that f. 12 is not extant.

The notation “f. 7v g M₁” (the “g” is for gap), which is not an example from the text, means that there is a gap here caused by the actual page break falling within a colophon, for example, or in a verse not found in other manuscripts. In this case, the precise point where the page change occurs should be sought in the apparatus.

Editorial additions

Editorial additions to the text are enclosed between angle brackets (“ $\langle$ ” and “ $\rangle$ ”). Such additions are, however, used only for chapter heading and for numerals not given in any of the manuscripts (for the latter, see below).

Structure of the critical apparatus

As noted above, each line of the established text is given a number and contains a *pāda* of a verse. In the apparatus, the beginning of each verse is noted in bold. After this follow notes on the numbering of the verse in the manuscripts, if there are any differences with the number that the verse has been given in the established text. At this point, other notes might also be found, such as whether a manuscript has a heading for the given verse, and so on. Then follow the variant readings, which are presented as follows.

The first variant noted for a given line is preceded by the number of that line. If a variant reading stretches over more than one line, this is indicated also. Now to the variant readings themselves. First a lemma, i.e., a number of syllables from the established text for which there is a variant in at least one of the manuscripts, is given. After the lemma follows a “]”. Then follows the variant reading or readings, each followed by the manuscript or manuscripts in which they are found. For example, in the apparatus for verse 2.2.1^a, we find

जनन] जननि M₃, जन V₄

Here the lemma is the three syllables जनन. In place of जनन, M₃ has जननि, and V₄ has जन (meaning that the scribe left out a syllable by mistake). When the abbreviation “om.” is given after a lemma, it means that the lemma is omitted in the manuscript or manuscripts in question.

The variant readings are listed alphabetically according to the manuscript represented by the earliest letter of the alphabet and the lowest number having the particular variant reading. For example (not an example from the text of the *Siddhāntasundara*):

शशाङ्कसूर्यौ] चन्द्रसूर्यौ B₂B₄R₂, शशाङ्कभानू B₃IV₂V₅, चन्द्रभानू M₁M₂V₄

If there are more syllables in a variant than in its lemma, it means that the scribe wrote a larger portion of text in place of the lemma, not that the extra syllables are part of the neighboring text (the neighboring text might have variants as well, but if so, it is noted with another lemma); if there are fewer syllables, it means that the scribe omitted them. The only exception to this is when the lemma is a number; for this, see the section below on representation of numerals in the edition.

Note that a lemma need not be a word. It can be a word, a part of a word, a word and a part of another word, parts of two words, and so on. In other words, it might be necessary in some places to take note of other variants in the verse to see how a specific word differs from the established text in a given manuscript. The reason that variants are noted in this way rather than word by word is that Sanskrit words often bind themselves to their neighbors through *sandhi* operations (phonetical combination of letters in sentences of Sanskrit words). An example is तद्विज्ञानशून्यश्चिरम् in verse 2.1.8^d, where conjunct syllables unite the words तत् and विज्ञानशून्यः, and the words विज्ञानशून्यः and चिरम्. Were we to list a variant for the word चिरम् by itself, we would have to separate the conjunct चि into श् and चि, but no manuscript does this. While other approaches could have been followed without creating major confusion, it is felt that the approach adopted is more true to the text as it appears in the manuscripts.

Principles followed in establishing the text of the *Siddhāntasundara*

In the critical apparatus, the following principles have been followed:

1. Variations such as *sandhi* errors, *sandhi* variations, and other minor spelling irregularities, such as स्छ for स्थ, दृक्षेप for दृक्षेप, छ or त्छ for त्य, and छ for च्छ, have not been recorded. If such variations are common in a manuscript, it is noted in the description of it.
2. Scribes almost always use an *anusvāra* for the proper class-nasal, and thus write क्रान्ति and शशाङ्क as क्रान्ति and शशाङ्क. The established text always has the proper class-nasal, but variants with an *anusvāra* are not recorded in the critical apparatus.
3. Omissions or inclusions of *avagrahas* have not been recorded, unless where two different interpretations are possible.
4. Corrections to the text of any kind, as well as any kind of marginalia have been recorded. If it is possible to determine whether the correction or marginalia were done by another hand, this has been noted.
5. When numerals are found in a manuscript, the apparatus will record precisely how they are represented (see the notes below on scribal representation of numerals and the representation of numerals in the established text).

The variant given after a lemma in the critical apparatus is precisely what is found in the particular manuscript cited. In other words, no *sandhi* corrections and the like have been applied to the variant; they are precisely as they read in the manuscripts.

Notations used in the critical apparatus

Round brackets around one or more syllables in a variant reading indicate that these syllables were added as an afterthought at some point in the copying process. The subscript of the final bracket indicate where the addition is made: “marg” means in the margin, “supl” above the line, and “subl” below the line. If there is no subscript, the addition is made in the line itself. When the subscript is followed by “s”, the addition was made by another hand. No “s” means that the addition was made by the scribe, or that it is not possible to determine whether it was made by the scribe or by someone else.

Square brackets around one or more syllables indicate that the syllables in question have been erased. In many cases it is impossible to say whether the scribe or someone else did the erasing, so no attempts are made to clarify this. Note that syllables are erased in various ways by scribes, such as blotting out the syllable, marking it as erased by a stroke, and so on. In the first case, it might be impossible to make out the original syllable.

The character “x” in a variant reading indicates an illegible syllable. The character “z” indicates a syllable that is unreadable due to the photocopying process (i.e., if it is faint in the photocopy; it was originally highlighted with, say, yellow pigment that now obscures it in the photocopy; and so

on), and the character “w” indicates a syllable that is unreadable due to damage to the manuscript (i.e., a hole, a tear, and so on). A raised question mark, i.e., a “?”, after a syllable indicates that this seems to be the most likely reading, but that the syllable is unclear and the reading thus uncertain.

When a scribe was not able to read a syllable in the manuscript that he was copying from, he generally wrote in its place a short horizontal line, i.e., the horizontal line of a Devanāgarī character without a character attached. In the apparatus, this is represented by a “~”.

Examples of the notations used

In order to make the description of the notations used in the critical apparatus more clear, a number of examples will be given here. None of them is from the text of the *Siddhāntasundara*, M₁ being used just as an example.

1. शशिसूर्यौ] (शशि)_{marg,s} सूर्यौ M₁

means that the syllables शशि were added in the margin by another hand;

2. शशिसूर्यौ] शशि (सू)_{marg} र्यौ M₁

means that the syllable सू was added in the margin by the scribe (or that it is not possible to say for sure whether or not it was added by the scribe or someone else);

3. शशिसूर्यौ] (श)_{supl,s} शिसूर्यौ M₁

means that the syllable श was added above the line by another hand;

4. शशिसूर्यौ] शशि [भानू] (सूर्यौ)_{marg,s} M₁

means that the scribe wrote शशिभानू, but that भानू was erased, and another hand wrote सूर्यौ in the margin to replace it;

5. शशिसूर्यौ] श (ि) श [ि] सूर्यौ M₁

means that the scribe originally wrote शशीसूर्यौ, but the the ī-vowel mark was erased and an i-vowel mark added to replace it;

6. शशिसूर्यौ] श [ि] शिसूर्यौ M₁

means that the scribe wrote शाशिसूर्यौ, but the ā-vowel was erased, thus correcting the reading to शशिसूर्यौ;

7. शशिसूर्यौ] श x सूर्यौ M₁

means that the second syllable is illegible;

8. शशिसूर्यौ] श z सूर्यौ M₁

means that the second syllable is unreadable due to the copying process;

9. शशिसूर्यौ] श w सूर्यौ M₁

means that the second syllable is unreadable due to damage to the manuscript;

10. शशिसूर्यौ] शशि_xसूर्यौ M₁

means that an illegible syllable was erased between शशि and सूर्यौ (note that the illegibility of the syllable can be due either to its being unclear or to its being crossed out);

11. शशिसूर्यौ] शशिसू[?]र्यौ M₁

means that the reading of the syllable सू is uncertain; and

12. शशिसूर्यौ] शशि⁻र्यौ M₁

means that the scribe, unable to read the third syllable, wrote a “-” in its place.

In addition to these conventions, more detailed verbal explanations are used to describe the variant readings when necessary.

Scribal representation of numerals

The occurrence of numerals in the manuscripts and their relationship with the text have already been discussed. At this point, the way numerals are inserted in the text by scribes and how numerals are handled in the established text and in the critical apparatus will be discussed.

When representing numbers in the following, we will use a system introduced by Otto Neugebauer, in which a semicolon is used to separate a sexagesimal number’s integral and fractional parts, and commas to separate the individual sexagesimal digits.²⁵⁰ As such, ० । ४८ । ५ । ३७ । १९ will be written as 0;48,5,37,19, १२९७ । १ । २ । ३१ as 1297;1,2,31, and १५ । ० । ३ as 15;0,3.

Scribes insert numerals in the text in a number of ways. There is no consistent rule followed by all. In fact, most often there is no consistent way that numerals are inserted within any given manuscript.

The most common way that numerals are added to the text in the manuscripts is to write them directly in the lines of the text at an appropriate place. An example (not taken from the *Siddhāntasundara*) is:

शरदन्त ३२५

However, numerals are sometimes written above the word to which they belong:

३२५
शरदन्त

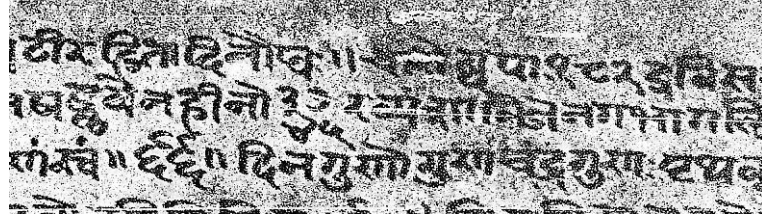
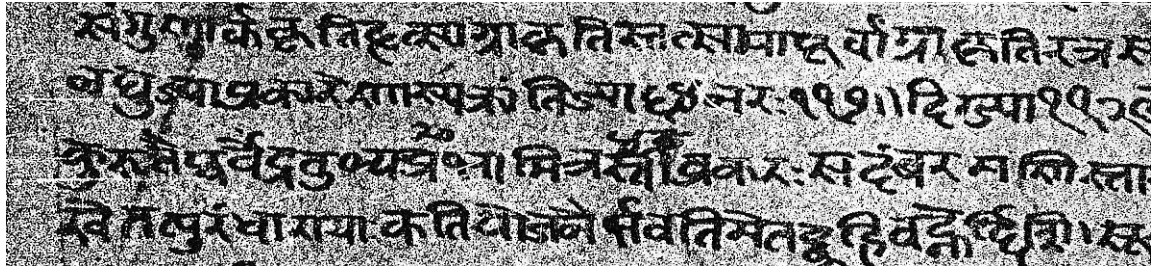
A number with a fractional part, such as 31;40, is generally inserted in the text as in this example from 2.2.17^a:

त्र्यंशोनाः शशिनो रदाः ३१ । ४०

However, scribes sometimes also write the integer and sexagesimal parts in a column:

त्र्यंशोनाः शशिनो रदाः ३१
४०

²⁵⁰See [59 . 12–13].

Figure 1.8: Misplacement of numerals on f. 5v in B₅Figure 1.9: Misplacement of numerals on f. 13v in B₅

A list of numbers is generally given by the scribes as in this example from 2.1.3^c:

युगगुणयुगलेन्दुभिः ४ । ३ । २ । १ पृथग्घ्रा

Note that here the string ४ । ३ । २ । १ does not mean 4;3,2,1, but rather “4, 3, 2, and 1”.

When a non-integral number is represented by placing the integer part and the sexagesimal parts on top of each other in a column, it can happen that the lower entries of the column are misidentified as belonging to a different line. Figure 1.8 shows an example of this taken from f. 5v of B₅. The example spans 2.1.65–66. In the manuscript that the scribe of B₅ was copying from, the number 182;37,45 in 2.1.65^c must have been written

१८२
३७
४५

However, this was misread by the scribe, who, thinking that the lower rows of the column belonged to another line, kept १८२ in 2.1.65^c, but placed ३७ at the end of 2.1.66^a.

Figure 1.9 shows a second example of this taken from f. 13v of B₅. Above certain words in the third line of the scan, the numbers २० and ४८ are written. As they stand, it appears as if they belong to words in the third line, but in reality they belong, respectively, to the numbers ६४ and ११७ in the second line, which actually should be ६४ । २० (i.e., 64;20) and ११७ । ४८ (i.e., 117;48).

This is one of the reasons that it is important that the critical apparatus documents precisely how numerals are represented in the manuscripts.

Another usage of numerals should also be noted here. When a scribe has written two successive syllables in the wrong order (such as कश instead of शक, written by the scribe of B₅ in 2.1.4^d), a

correction is sometimes made by placing a २ over the first syllable and a १ over the second so as to indicate the order in which they are to be read. For example, we find the following in B₅:

२ १
क श

Representation of numerals in the established text of the *Siddhāntasundara*

In the established text of the *Siddhāntasundara*, numerals are always placed in the text after the word to which they belong (most often a *bhūtaśaṅkhyā* word or compound), and fractional parts are separated using *daṇḍas*. In other words, they are always given as follows (example taken from 2.2.17^a):

त्र्यंशोनाः शशिनो रदाः ३१ । ४० क्षितिसुतान्नेत्राद्रयो ७२ ऽष्टाश्विनो २८

In some places there will be a *bhūtaśaṅkhyā* word or compound for which none of the manuscripts gives numerals. In this case, for the sake of consistency, numerals are generally added in angle brackets, such as in this example from 2.1.58^a:

श्रुतयो <४> दिनेशाः <१२>

Chapter 2

golādhya section 1

bhuvanakośādhikāra

Cosmology

~ INVOCATION ~

(1) I praise [Gaṇeśa of] auspicious form, primeval and imperishable, dear to his devotees [or to whom his devotees are dear], and on whose forehead the Moon is [resting], on whose temples a line of black bees are congregated in search of nectar, on whose throat a serpent is shining fervently, at whose two feet the hearts of the gods [dwell], and whom even Brahman, desiring to create the three worlds, served for the sake of unhindered success.

Jñānarāja opens the *Siddhāntasundara* with an invocation praising the elephant-headed deity Gaṇeśa. The verse could also be taken to refer to the deity Śiva, although the reference to bees on the temples of the deity seeking nectar seems to indicate Gaṇeśa, as the sweat from an elephant's forehead is considered to attract bees in the Indian tradition.

~ INVOCATION ~

(2) I, Jñānarāja, am composing the *Siddhāntasatsundara*, which gives bliss to the learned, and which is ingenious and correct, after bowing down to my teachers as well as to [the goddess] Bhuvaneśvarī, [whose] worshipper

[though filled with] inner night may become one who has destroyed [his] darkness and possessed of increasing arts through the ray-like syllables of her name, which sound as they occupy his body [in a *yantra*, i.e., an object or a symbol used for worship, or as they are deposited on the worshipper's body ritually] in sequence.

In this verse, there is a distinct flavor of Tantrism, a term covering a number of esoteric traditions in India whose teachings are given in texts known as *tantras* (not to be confused with the *tantras* of the astronomical tradition). Here Jñānarāja invokes Bhuvaneśvarī, a Hindu goddess worshipped in certain forms of Tantrism.

~ THE SOURCE OF THE SIDDHĀNTASUNDARA ~

(3) The foremost knowledge concerning the nature of the motion of the planets and the stars that was related to Nārada by the four-faced [Brahman] was composed in its entirety by the sage bearing the name Śākalya. In my own verses, I am presenting precisely that [knowledge], accompanied by demonstrations.

Here the source of the *Siddhāntasundara* is given as the *Brahmasiddhānta*, a treatise claiming to have been narrated by the deity Brahman to the sage Nārada and recorded by the sage Śākalya. This has been discussed in the Introduction (see p. 36).

~ TANTRAS AND SIDDHĀNTAS ~

(4) Eight *tantras* were written by Brahman, Sūrya, Soma, Vasiṣṭha, Romaka, Pulastya, Brhaspati, and Garga. The difficult method of planetary computations is [given] in them. For crossing over the ocean [of this difficult science] by means of demonstrations [of the formulae] of their [i.e., the *tantras*'] mine of jewels, boats [in the form] of *siddhāntas* were made by Bhojarāja, Varāhamihira, Jisṇu's son [Brahmagupta], Caturveda [Prthūdakasvāmin], Āryabhaṭa, and the good Bhāskara [II].

Jñānarāja here supports the tradition that the science of astronomy was received through eight revelations written down in eight treatises. These eight treatises are normally called *siddhāntas*, but Jñānarāja here calls them *tantras*, reserving the term *siddhānta* for the subsequent treatises written by human beings. See the Introduction (p. 38).

~ IMPORTANCE OF JYOTIḤŚĀSTRA IN THE RITES OF THE VEDAS ~

(5) This triad of *vedas* came forth for the sake of rites such as sacrifices and so on. For computing that which relates to direction and time [in the performance of these rites], this *śāstra*, which is to be studied by the twice-born, was taught by the ancient sages.

In the rites prescribed in the *vedas* and ancillary literature, correct timing and orientation with respect to the cardinal directions is very important. This is one of the topics of *jyotiḥśāstra*.

~ IMPORTANCE OF CORRECT TIMING ~

(6) It is said by the ancient sages that he who begins his religious observances during any forbidden time, such as during the intermission of study, is not a twice-born.

[And the ancient sages have also said that] a woman who has the same *ghaṭikā* is a sister [i.e., she is not marriageable, and to marry her is to commit incest]. And an action [performed] in confusion about direction [i.e., which direction is east] is fruitless, and so are observances on the [special] *tithis* and so on [i.e., they are fruitless when done in the wrong direction].

That a woman has the same *ghaṭikā* as a given man means that she has the same ascendant (the ascendant is the point on the horizon where the ecliptic is rising) in her birth chart as the man. In this case, the woman is to be considered a sister, and the marriage between the two is forbidden. However, whether this is the case can only be known through the science of astronomy, the importance of which is thus emphasized.

~ THE SIX VEDĀṄGAS ~

(7) The lord of the gods in the form of the *veda* conquers to protect the world. That which is his mouth is *vyākaraṇa*; *nirukta* is said to be his ear; likewise, his nose is *śikṣā*; *jyotiṣa* is his eye; his pair of hands is *kalpa*; and his pair of lotus-like feet is *chandasa*. In this way the six-limbed personified *veda* is to be understood with reference to meaning and recitation.

The *vedāṅgas* (literally, limbs of the *veda*) are six auxiliary disciplines through which the *veda* can be properly understood. Together these disciplines are said to form the body of the *veda*, as it is

through them that the a person understands the *veda* and becomes able to practice its doctrines. The first *vedāṅga* mentioned by Jñānarāja is *vyākaraṇa*, the science of grammar, which is considered the face of the embodied *veda*; the second, *nirukta*, the science of the etymology of the words of the *veda*, is considered the ear; the third, *śikṣā*, the science of correct pronunciation of the words of the *veda*, is considered the nose; the fourth, *jyotiṣa*, is considered the eye; the fifth, *kalpa*, the science of ritual, is considered the hands; and the sixth, *chandas*, the science of poetic meters in the *veda*, is considered the feet. Note that there is more than one meaning of the Sanskrit word *kalpa*. Here it refers to the science of ritual, but it also (as in verse 8 and verse 12) denotes a world age of duration 4,320,000,000 years. This span of time is the life span of the world. At the beginning of the *kalpa*, the world is created, and at its end it is destroyed. The *kalpa* corresponds to a day in the life of the creator-god Brahman. The world ages will be explained in 2.1.2–3 and the commentary thereon.

~ THE DIVISION OF JYOTIṢA ~

(8) ***Jyotiḥśāstra* has three divisions: astronomy, astrology, and omens. The computation of the planets [i.e., of planetary motion] is the foremost part of the [astronomical treatises called] *tantras*. A *siddhānta* is [a treatise] where the nature of the nectar relating to the planets as well as their motions and measures in a *kalpa* [is given], and computation is given as well with demonstrations.**

The division of *jyotiḥśāstra* given here is a traditional one.¹ In this verse, Jñānarāja explains in more detail his distinction between *tantras* and *siddhāntas*: a *tantra* contains the computational matters, whereas a *siddhānta* contains demonstrations (*vāsanās*) as well.

When Jñānarāja speaks of the “nectar relating to the planets, and so on”, he is using what is a common metaphor in India. The meaning is either that the *siddhāntas* present the best of the science of astronomy, or that this science is nectar, i.e., a high and important science.

~ CREATION ACCORDING TO SĀṆKHYA ~

(9–10) **First, the principle of intellect arose from a combination of original nature and self for the creation of the three [worlds]. The sense of “I” arose from the this source. From that the basic element of sound arose. From that the sky arose. From that the basic element called contact arose. [From that] the wind arose. From the wind the basic element of form arose. From that light arose. From that the basic element of taste arose. [From**

¹See [74 . 1].

that] water arose. From water the basic element of smell arose. From that earth arose. From the joining together of these this [world] arose.

Sāṅkhya is one of the schools of classical Indian philosophy. It is a dualist philosophy that regards the world as being composed of two eternal elements: *puruṣa* (self) and *prakṛti* (nature).² The unfolding of creation according to this system of philosophy is here briefly outlined by Jñānarāja. It is the first of three creation accounts that he will present.

~ CREATION ACCORDING TO THE PURUṢASŪKTA OF THE ṚGVEDA ~

(11–12) The universe is resting in the belly of the All-Creator. From his two feet the Earth [came to be]; from his navel the [intermediate] region known as the atmosphere [came to be]; from his head the heaven [came to be]; from his mouth [the deities] known as Indra and Agni [came to be]; and the deity of wind [Vāyu] arose from his breath. Thus it is said in the *veda*. The Moon is dwelling in his heart; the Sun dwells in his eye; from his ear all the cardinal directions arose. This is the path of creation in the present *kalpa*.

This account of creation is taken from a famous creation hymn, the *puruṣasūkta*, of one of the most sacred texts of Hinduism, the *Ṛgveda*.³

~ CREATION ACCORDING TO THE ŚĀTAPATHABRĀHMAṆA ~

(13–19) Awakened by the middle vital air, the seven vital airs, which merged into the Primeval Person [i.e., the deity Viṣṇu] during the previous *pralaya* [destruction], created seven Persons. By them, having become one, the Expansive Person [i.e., Brahman] was created. He appeared from a lotus. As all this [i.e., the universe] is fashioned by him, it is called his creation.

At first, Brahman created the waters from his own speech. [Then] he entered [the waters] along with the triple [sacred science] by means of a portion of himself. An egg arose. From [the embryo of] that [egg] Agni [the god of fire] arose here. After [Brahman] pressed the pair of [half-]shells [of the egg] together and put them in the water, the Earth was created. Then

²See [89].

³*Ṛgveda* 10.90.13–14.

he joined with that [Earth] possessing a portion of Agni. An egg arose, and Vāyu [the god of wind] arose from within that [egg].

At that very place, the atmosphere came to be from the shell of the egg. Joining with that [sky], having joined his own portion with Vāyu [the god of wind, or merely wind], he made an an egg. This Sun arose from that [egg]. In that place, the heaven was [born] from the shell of that egg and the sunbeams [arose] from the juice sticking to the half-shell. Joining with that [sky] by means of his own portion [and] along with a portion of the Sun, an egg appeared.

The Moon arose from within that egg. The multitude of stars arose from the water flowing in this place. The cardinal directions [arose] from the half-shell of that [egg], and the intermediate directions [arose] in like manner from the matter sticking to that [shell].

Having created the worlds from the combination of speech and mind, the All-Creator created the eight [deities known as the] Vasus by means of eight months. Likewise, the [deities known as the] Rudras, as well as the twelve [solar deities known as the] Ādityas, and the [deities known as the] Viśve Devas.

The Creator placed Agni [fire] and the Vasus on the Earth, [deities known as] the Maruts and the group of [deities known as] Rudras in the atmosphere, the Ādityas associated with the Sun in the sky, and the Moon accompanied by the Viśve Devas in the cardinal directions.

Thus it is taught in the text of the beginning of the sixth *kāṇḍa* [section] of the *Śatapathabrāhmaṇa*. Here [in this work] a particular path of creation is given. There is oneness of both creation [accounts when examined] with laudable reflections. If [however] there is a difference in some place, it is to be understood through *kalpabheda*.

The most voluminous of the three creation accounts presented is this one from the *Śatapathabrāhmaṇa*.⁴

The term *pralaya* refers to the destruction of the universe. This is followed by a new creation.

The association of the eight Vasus with months in verse 17 is unclear; the *Śatapathabrāhmaṇa* has *drapsa*, “drop”, instead of *māsa*, “month”.⁵

⁴*Śatapathabrāhmaṇa* (Mādhyandina recension) 6.1.1.1–6.1.2.10.

⁵*Śatapathabrāhmaṇa* 6.1.2.6.

The term *kalpabheda* (literally, different *kalpa*) is often used by the interpreters of the *purāṇas*. If inconsistencies occur in two accounts of the same story, they are explained by saying that the two accounts took place in two different world ages (*kalpas*). What this means is that certain events are considered to take place in every creation, i.e., in every *kalpa*, but the details might differ. As such, inconsistencies in myths or religious narratives given in different sacred texts can be explained without invalidating any of them. Śrīdharasvāmin, the renowned commentator on the *Bhāgavatapurāṇa*, invokes *kalpabheda* twice.⁶ Here, of course, the word *kalpa* refers to the world age of 4,320,000,000 years (see commentary on verse 7).

~ THE PERIOD OF CREATION ~

(20) **The circle of the Earth, the oceans, the mountains, the planets, and so on were created in order in 474 times 100 divine years [i.e., 47,400 divine years] commencing at the beginning of the *kalpa*. Then all the planets were placed on the circle of stars.**

That a period of 47,400 divine years, during which the Earth, planets, and so on are created, occurs at the beginning of the *kalpa* is a basic idea of the *saurapakṣa*.⁷ Since a divine year is equal to 360 of our years, the period is equivalent to 17,064,000 years. This period is called *śṛṣṭikāla* in Sanskrit. It should be noted that since the planets are being created during this period, there is no planetary motion during the *śṛṣṭikāla* (see also 2.1.7, which condemns the idea that planetary motion begins at the beginning of the *kalpa*).

~ SPHERICITY AND SUPPORT OF THE EARTH ~

(21) **The Earth-sphere is indeed globular. The oceans are located as girdles on that [Earth-sphere] on which, in the middle, on the top, and at the bottom, there are gods, men, demons, mountains, and trees.**

Just as the protuberance of a *kadamba* flower is supporting its filaments, so this preeminent [Earth-sphere], which is holding [all these gods, men, and so on], rests immovable in space, its great weight supported by the *avatārapuruṣas*.

In the Indian tradition, there are a number of ring-shaped oceans situated on the Earth as girdles (see verse 41). The *avatārapuruṣas* are the incarnations of the deity Viṣṇu that, according to the Indian tradition, hold up the Earth. The *kadamba* (*anthocephalus cadamba*) flower is shaped as

⁶Commentary on *Bhāgavatapurāṇa* 5.16.27–28 and 12.11.39 (the edition used is [93]). See also [52 . 355].

⁷See *Sūryasiddhānta* 1.24.

a ball with tiny white petals that point in all directions. The analogy with the Earth, which has people, and so on, all over is clear.

~ AN ARGUMENT FOR THE SPHERICITY OF THE EARTH ~

(22–23) Since a planet located [directly] above the city of Laṅkā is [due] south on the horizon of [the mountain] Meru, [due] west on the horizon for a person in Yamakoṭi, [due] east on the horizon in Romakapura, and [due] north on the horizon from Vaḍavānala, therefore the Earth indeed has the form of a sphere.

Since this good argument for the sphericity of the Earth which Pṛthūdaka-svāmin gives is not acquired by means of the *pramāṇas*, therefore low-minded people do not value it.

Laṅkā, Romakapura, Siddhapura, and Yamakoṭi are four imagined cities on the terrestrial equator, each being 90° from its two neighbors. Laṅkā is famous in Indian mythology as the capital of the demon-king Rāvaṇa, who was killed by the deity Rāma. Meru, the legendary mountain of Indian mythology, is on the north pole, and Vaḍavānala is an underwater fire at the south pole.

An argument for the sphericity of the Earth, given by Bhāskara II and Pṛthūdakasvāmin,⁸ is the following. When a planet is directly above Laṅkā, it is on the horizon for someone at Meru (note that the southern direction is not uniquely determined at Meru, and the northern direction is similarly not uniquely determined at Vaḍavānala), due east on the horizon for someone in Romakapura, due west on the horizon for someone in Yamakoṭi, and on the horizon for someone at Vaḍavānala.

In Indian philosophy, the *pramāṇas* are ways of acquiring knowledge. The number of *pramāṇas* varies in different texts, but the list generally includes direct observation, logical inference, and supernatural authority. That the argument given in the verse is weak due to its not being based on the *pramāṇas* is explicitly noted by Jñānarāja.⁹

~ ANOTHER ARGUMENT FOR THE SPHERICITY OF THE EARTH ~

(24) For a traveler who is facing the polestar [i.e., traveling north or south] or facing horizontally [i.e., traveling east or west], for each *yojana* [traveled] the Earth is said to create, in order, an elevation of the nonmoving [polestar] situated far from the Earth, or to produce the comparable experience of sameness [of elevation]. For this very reason, it is like a ball.

⁸Pṛthūdakasvāmin presents this argument in his commentary on *Brāhmasphuṭasiddhānta* 21.1.

⁹For the defects of the argument and Cintāmaṇi's treatment of it, see [51 . 505].

A *yojana* is a measure of distance used in the Indian tradition. The value of a *yojana* differs in various contexts, but is generally considered to be between $2\frac{1}{2}$ miles and 9 miles.

The idea of the verse is that if one travels east or west, no change in altitude (elevation) above the horizon is perceptible for the polestar is seen, whereas a change in altitude is seen when traveling north or south.

~ ELEVATION OF THE POLESTAR ~

(25) For a traveler who is 14 *yojanas* north of his own region the circle of the *nakṣatras* [i.e., the ecliptic], which is directed towards the polestar, is depressed from the zenith towards the south, and the polestar has an altitude of 1 degree above the horizon.

According to the verse, when traveling 14 *yojanas* north, the polestar is elevated 1° . Let c be the circumference of the Earth in *yojanas*. Since c corresponds to 360° , we get the proportion

$$\frac{1}{14} = \frac{360}{c}, \quad (2.1)$$

which yields

$$c = 14 \times 360 = 5040. \quad (2.2)$$

For this result, see also 2.3.18. Later in this chapter (verse 74), however, the circumference will be given as 5059 *yojanas*.

~ EARTH'S CIRCUMFERENCE VIA A THOUGHT EXPERIMENT ~

(26) When the Sun was on the eastern horizon [i.e., when it was rising] a swift-moving man commenced an eastward journey of 10 *yojanas* holding a sand clock in his hand. Learning that the time [of sunrise at his destination] was 7;12 *palas* less than sunrise at his origin [on the day before], the Earth was understood by him to indeed be in the form of a sphere measuring 5000 [*yojanas* in circumference].

Here Jñānarāja presents a thought experiment. At sunrise, a man carrying a sand clock in his hand travels 10 *yojanas* eastward. When the next sunrise occurs, he notes that it does so 7;12 *palas* (a unit of time equal to $\frac{1}{60}$ *ghaṭikā*, see the Introduction, p. 22) earlier than on the previous day. Since this difference in time corresponds to the 10 *yojanas* that he traveled, the man is able to compute the circumference of the Earth.

The text literally says *seṣvaṃśādrīpalādhikam tu samayaṃ*, “time greater by 7;12 *palas*”, but the meaning must be that sunrise occurred 7;12 *palas* earlier at his destination than at his origin on the previous day, as reflected in the translation.

The value of the circumference comes out from a simple proportion. Let c be the circumference of the Earth. There are 3600 *palas* in a nychthemeron (i.e., a day and a night, or 24 hours), and so

$$\frac{c}{10} = \frac{3600}{7;12}, \quad (2.3)$$

which gives us that

$$c = \frac{10 \times 3600}{7;12} = 5000. \quad (2.4)$$

Note that this holds true only if the man was traveling along the terrestrial equator.

~ CRITIQUE OF MISREPRESENTATION OF THE PURĀṆAS ~

(27) [Even] after seeing the word *bhūgola* [Earth-sphere] being used in the *purāṇas* as well as the phrase “Meru is north of all [places]”, people who are disposed to obstinacy say that the entire Earth is [flat] like the surface of a mirror. But none of them know the meaning of the *purāṇas*, nor that the spherical nature of the Earth is established by excellent demonstrations.

The word *bhūgola*, which literally means “Earth-sphere”, is used five times in the *Bhāgavatapurāṇa*.¹⁰ That it occurs in the *purāṇas* is the basis of Jñānarāja’s argument that the author of these texts knew that the Earth is spherical.¹¹

~ THE EARTH ONLY APPEARS FLAT ~

(28) The likeness to the surface of a mirror mentioned in the *purāṇas* [applies only] to a one-hundredth part of the Earth, not the [entire] sphere of the Earth. A one-hundredth part of the circumference [of the Earth] is seen [as being straight] like a stick. Therefore the sphere of the Earth appears as if it is flat to human beings.

The statement of the *purāṇas* that the Earth is flat is not to be taken literally. It merely reflects that a small section of it appears flat to a human being.

~ ESTABLISHING THAT THE EARTH HAS SUPPORT ~

(29–30) It is said in the treatise of Bhāskara [II] that the logical flaw of

¹⁰ *Bhāgavatapurāṇa* 3.23.43, 5.16.4, 5.20.38, 5.25.12, and 10.8.37.

¹¹ Pingree told me that he believed that the term had spread from the astronomical tradition to the greater tradition and thus should simply be taken as “Earth” when occurring in the *purāṇas*.

infinite regression arises when an embodied supporter of the Earth is assumed, and that therefore firmness should be taken as an inherent quality of the Earth, just as heat is a quality of fire and fluidity of water. That [argument] is not correct.

Let Śeṣa and the others, who are mentioned in the *purāṇas*, be holding steady the motion of the Earth. Since they are mentioned in the *vedas* regarding the motion of the planets and the cage of the stars, what is the fault with them [as being the support of the Earth]?

Moreover, if there is a quality characterized by firmness in the Earth, [then] why [is that] not [so] in its parts, just as there is fluidity in drops of water, heat in sparks of fire, and so on?

According to Bhāskara II, if we assume a support of the Earth, we end up with an infinite regress. For what is the support of the support, and the support of the support's support? It is better, says Bhāskara II, to assume that the Earth has an inherent quality of firmness, just as fire has the quality of heat and water that of fluidity. In other words, the Earth is its own support.¹²

Jñānarāja disagrees. If the Earth has the quality of firmness, why is this not so for its parts? If we place a piece of earth in the air it will fall. However, even small drops of water and sparks of fire have the respective qualities of fluidity and heat.

Śeṣa is the incarnation of Viṣṇu in the form of a serpent. He is one of the *avatārapuruṣas* mentioned in verse 21.

In 30^a, it is perhaps better to read *bhāra* instead of *cāra*, and translate the passage as: “Let Śeṣa and the others, who are mentioned in the *purāṇas*, be supporting the weight of the Earth.” However, all manuscripts but one have *cāra*, and furthermore this reading is the one commented upon by Cintāmaṇi, who glosses it as *calana* and *adhogamana*, the latter meaning “downwards motion”. The meaning is, then, that the support of Śeṣa and other divine beings prevents the Earth from falling downwards.

~ A FURTHER ARGUMENT FOR THE EARTH HAVING SUPPORT ~

(31) A vulture, which has only little strength, rests in the sky holding a snake in its beak for a *prahara*. Why can [the deity] in the form of a tortoise, who possesses an inconceivable potency, not hold the Earth in the sky for a *kalpa*?

A *prahara* is a period of time equal to about 3 hours. The description given of the vulture fits

¹²See *Siddhāntaśiromaṇi*, *golādhyāya*, *bhuvanakośa*, 4–5.

the serpent eagle better than the vulture, which does not eat snakes.¹³ The tortoise referred to is the incarnation of Viṣṇu in the form of a tortoise, one of the *avatārapuruṣas* of verse 21.

~ ANOTHER ARGUMENT FOR THE EARTH HAVING SUPPORT ~

(32) **The statement that the Earth has a power of attraction is not [correct], since a dense object reaches the Earth fast, but a light object becomes attracted fast [?]. How can the Earth be unmovable without support?**

While the verse is not clear, the idea seems to be that a lighter object is more responsive to attraction, as it has less inertia.

~ THE NATURE OF “UP” ~

(33) **Half of the sphere of the Earth is above the ocean of salt. Meru is where the gods always stay. Indeed, it [Meru] alone has “upness”. The lower station is said in the good *purāṇa* to be in the place where the demons [stay].**

The ocean of salt is located along the equator (beneath it, in the southern hemisphere, are a number of ring-shaped oceans of other liquids (see verse 39)). The half of the sphere of the Earth above the ocean of salt is the northern hemisphere. Jñānarāja holds that only Meru is “up”, i.e., that “up” is an absolute entity, namely from the south pole towards the north pole. This differs from the astronomical tradition, which holds that “down” is always from one’s feet towards the center of the Earth. Jñānarāja is here following and reinterpreting the tradition of the *purāṇas*, according to which the demons are “below”.

For the cosmology of the *purāṇas*, see Introduction, p. 23.

~ DOUBT WITH REGARD TO THE NATURE OF “UP” ~

(34) **If this is so, why do these mountains, oceans, rivers, and men that are located below not fall into space? An inanimate, heavy object that is not supported is seen to fall down.**

If “up” is absolute, then why do beings and objects on the southern atmosphere not fall “down” into space? We see that an inanimate object always falls “down” towards the ground when left without support.

¹³See [52 . 363–364, fn. 50].

~ RATIONALE BEHIND THE ABSOLUTE NATURE OF “UP” ~

(35–38) What has been said is not to be doubted. Certain objects with qualities characterized by specific potencies can be different according to circumstances and place, just as Moon Stones, which are stones, melt [when exposed to moonlight] and the appearance of fire in Sun Stones, which are also stones. [Similarly,] diamonds float on water and a magnet attracts iron that is located very far from itself. Since the water in the ocean is very high like a mountain, ah! regions have multiple qualities.

On this half [of the sphere of the Earth, i.e., the northern hemisphere], a difference in language, appearance, conduct, and ability is seen in different regions. How much more [would this not be the case] for people in the other half [i.e., on the southern hemisphere]? Therefore, they possess a potency called “fixity”.

What is the use for us to go on at length talking in vain? The heavy, firm, and wide Earth is supported in space by the Deity, incarnated for the sake of preventing motion of the Earth. It is evident that he holds on everything that is located on the lower part of the Earth.

The rationale given here is, put briefly, that certain things have unusual properties. People are also different in different regions, and thus Jñānarāja postulates that a peculiar feature of people in the southern hemisphere is that they possess “fixity”, which allows them to remain on Earth and not fall “down” into space.

Sun- and moonstones are mythical stones that exhibit certain unusual qualities when exposed to the light of the Sun and the Moon, respectively. The former becomes fiery in sunlight, the latter melts in moonlight.

~ THE RING-SHAPED OCEANS ~

(39) The Ocean of Milk [lies] after the Ocean of Salt Water. The Ocean of Ghee [lies after the Ocean of] Yoghurt [which lies after the Ocean of Milk]. [Then comes] the Ocean of Sugarcane Juice and [then] the Ocean of Liquor. After that [lies] the Fresh Water Ocean.

According to the geography of the *purāṇas*, there are seven ring-shaped oceans filled with various liquids.¹⁴ The order of the oceans given here follows that given in the *Siddhāntaśiromaṇi*.¹⁵ This

¹⁴See [71 . 554].

¹⁵*Siddhāntaśiromaṇi*, *golādhyāya*, *bhuvanakośa*, 22–23.

account differs from that in the *purāṇas*.

~ THE SUBMARINE FIRE AND THE ORIGIN OF LIGHTNING ~

(40) In the center of the Ocean of Fresh Water lies Vaḍavāgni. From that [place], which is submerged into a large body of water, columns of smoke arise, which are carried in every direction in the sky. They dissolve when scorched by the rays of the Sun becoming the sparks of lightning.

On the south pole, in the center of the ocean of fresh water, lies Vaḍavāgni, a submarine fire.

~ JAMBŪDVĪPA AND THE ISLANDS OF THE SOUTHERN HEMISPHERE ~

(41) Jambūdvīpa is on the top part of the Earth north of the Ocean of Salt Water, which is lying [around it] like a girdle. Thus in the southern half [of the Earth], there are six islands located each between two oceans.

Jambūdvīpa, the region of the lands known to human beings, is on the northern hemisphere. In the southern hemisphere are six islands, each between two of the ring-shaped oceans. These islands are thus also ring-shaped.

~ ISLANDS OF THE SOUTHERN HEMISPHERE AND REGIONS OF JAMBŪDVĪPA ~

(42) [The six islands, in order, are:] Śākadvīpa, Śālmadvīpa, Kauśadvīpa, Krauñcadvīpa, Gomedadvīpa, and Puṣkaradvīpa.

The regions inside of Jambūdvīpa are called *varṣas*, or they are indicated by it [Jambūdvīpa].

The *varṣas* are the different regions of Jambūdvīpa.

~ THE IMAGINED CITIES ON THE EQUATOR ~

(43) The city of Laṅkā is in the ocean [the Ocean of Salt Water], which extends 130 *yojanas*. To the east of it at [the distance of] a quarter of [the circumference of] the Earth is Yamakoṭi. [East] of that [city at the same distance] is Siddhapura. And [east] of that [at the same distance] is Romakapura.

The ocean of salt water extends 65 *yojanas* on each side of the equator. The four cities mentioned earlier, i.e., Laṅkā, Romakapura, Siddhapura, and Yamakoṭi, are located in the middle of it. For these imagined cities, see also verses 22–23.

~ THE GEOGRAPHY OF THE NORTHERN HEMISPHERE ~

(44–49) Vaḍavāgni indeed is south of them and Meru is to the north of them. Such indeed are the six regions.

North of the city of Laṅkā is [the] Himālaya [mountain]. Then [the] Hemakūṭa [mountain], and then [the] Niṣadha [mountain].

Likewise, [north] from Siddhapura is [the] Śṛṅgavat [mountain], [the] Śukla [mountain], and [the] Sunīla [mountain, in that order]. [These mountains] meet the ocean [the Ocean of Salt Water] in the east and the west by their length [i.e., the lengthwise ends meet the ocean as described]. Between them [i.e., the mountains] is the location of the [different] *varṣas*.

Bhāratavarṣa is located in the region between Laṅkā and [the] Himālaya [mountain range]. [Then, north] from that [city of Laṅkā,] reaching up to [the] Hemakūṭa [mountain range] is Kinnaravarṣa. [The region] extending up to [the] Niṣadha [mountain range] is given as Harivarṣa by the wise.

Similarly, north of Siddhapura are Kuruvarṣa and Hiraṇmayavarṣa. [And north] from them is Ramyakavarṣa. Thus six [*varṣas* are described]. I will now explain the three western [*varṣas*].

The Mālyavat mountain is north of Yamakoṭi, while the Gandhamādana mountain is [north] from Romakapura. The two of them meet [the] Sunīla and Niṣadha [mountains]. [The region] between these four mountains is called Ilāvṛtavarṣa, the ground of which is beautiful, being covered with jewels and gold.

Meru, which resembles a lotus, is in its [i.e., Ilāvṛtavarṣa's] center, surrounded by mountain ranges on all sides.

Similar geographies are described in the *Siddhāntaśiromaṇi* and in the *purāṇas*.

Some of these regions can be identified as actual regions in the area of India. For example, the Himālaya mountains are a well-known mountain range. Other regions and mountain ranges, however, cannot easily be identified. The region known as Bhāratavarṣa is India.

~ DESCRIPTION OF MERU ~

(50–51) [The mountain Meru, which is] the abode of the gods is made up of gold and jewels; it pierces the Earth, appearing [above the surface] in both ends [i.e., at the north pole and at the south pole].

At its peak the gods sport. At its bottom the calm multitude of demons [dwell].

The three peaks on the mountain of the gods are multi-colored, full of shimmering gold and jewels, and the three cities [are located there]. In these [cities] Śiva, Viṣṇu, and Brahman [dwell] always. Beneath them are the eight cities of the divine rulers of the directions.

~ DIFFERENCES WITH THE ACCOUNT OF THE PURĀṆAS ~

(52) It is said that Bhadrāśvavarṣa extends from the city of Yamakoṭi up to the Mālyavat mountain. Ketumālavarṣa indeed extends from Romakapura to [the] Gandhamādana [mountain]. However, this is not how it is explained by those who are learned in the *purāṇas*.

The description given in the *purāṇas* (for example, the *Bhāgavatapurāṇa*) is indeed different than the one given here by Jñānarāja, who is following the account of Bhāskara II in the *Siddhānta-śiromaṇi*.

~ THE MOUNTAINS OF THE NORTHERN HEMISPHERE ~

(53) The Mandara mountain and the Sugandha mountain are lying east and south, respectively, from the abode of the gods [i.e., the mountain Meru]. The Supārśva and Vipula mountains are north and west, respectively, from the abode of the gods.

Since Meru is at the north pole, it does not make sense to talk about something being east, north, or west of Meru.

~ THE MAJOR TREES OF THE NORTHERN HEMISPHERE ~

(54) The good banners on the peaks of [these four] mountains are, in order, a *kadamba* tree, a *jambū* tree, a *pippala* tree [the sacred fig tree],

and a *vaṭa* tree. Vaibhrajaka, Dhṛti, Nandana, and Caitraratha are the groves to be known, respectively.

The modern botanical names of the trees mentioned are *adina cordifolia* for the *kadamba* tree, *syzygium cumini* for the *jambū* tree,¹⁶ *ficus religiosa* for the *pippala* tree, and *ficus indica* for the *vaṭa* tree. The latter is commonly known as the banyan tree.

~ THE LAKES OF THE NORTHERN HEMISPHERE ~

(55–56) In the groves on the mountains are lakes: the Aruṇa, and after that the Mānasa, and the Mahāhrada, and Sitajala. [Sitajala] is auspicious by virtue of its lotuses, and it is crowded with a multitude of geese playing on its waters.

The delightfully charming young women in the groves that are the abode of the god of love, [women] whose very dark eyes are like a multitude of restless bees [i.e., their glances are like restless bees] and whose faces are lovely and round like golden lotuses, stay in the water with the gods.

~ THE JAMBŪNADĪ RIVER ~

(57) The Jambūnadī [river] springs from the streams of fluid flowing from the *jambū* fruits there. Mixed with soil, it becomes the gold known as Jāmbūnada. This island [i.e., Jambūdīvīpa] is named after the pleasant abode of these celebrated trees.

When the fruits from the *jambū* trees there fall to the ground they break and release their juice, which forms a river. The liquid of this river is then mixed the soil and a type of gold known as Jāmbūnada is formed from this combination.

~ THE DESCENT OF THE GAṄGĀ ~

(58) The [heavenly] Gaṅgā fell from the sky onto [the] Meru [mountain], flowed into the lakes on the peak [of Meru] high upon the supporting mountains, [and then] flowed into Bhadrāśvavarṣa, Ketumālavarṣa, Kuruvarṣa, and Bhāratavarṣa; it gives liberation even in *kaliyuga* to those who

¹⁶While the *jambū* tree, after which Jambūdīvīpa is named, is almost always identified with the rose apple tree (*syzygium jambos*), Wujastyk has shown that it actually is a plum tree (*syzygium cumini*) (see [106]).

submerge themselves in it.

The stream of the heavenly Gaṅgā flows into the four regions mentioned after landing on the peak of Meru. The stream that enters Bhāratavarṣa is the river Ganges in India, a river considered sacred in Hinduism.

For the *kaliyuga*, see commentary on 2.2–3.

~ THE NINE DIVISIONS OF BHĀRATAVARṢA ~

(59) Now, the interior of Bhāratavarṣa is said [to be composed of nine] divisions, [namely] Aindra, Kaśeru, Tāmraparṇa, Gabhastī, Kumārika, Saumya, Nāga, Vāruṇa, and Gāndharva.

~ THE MOUNTAIN RANGES OF BHĀRATAVARṢA ~

(60) The [seven] mountains [i.e., mountain ranges] in Bhāratavarṣa are Māhendra, Śukti, Malaya, Ṛkṣaka, Pāriyātra, Sahya, and Vindhya. [In this way] all the divisions on the surface of the Earth with their great mountains, towns, forests, lakes, and so on are described. Afterwards [the interior of the Earth] from the *pātālas* are narrated.

The Sahya and Vindhya mountain ranges are actual mountain ranges in India. The identification of the others, however, is not straightforward. The seven *pātālas* are subterranean worlds, the names of which will be given in the next two verses.

~ THE SUBTERRANEAN WORLDS ~

(61–62) In the hemisphere of the Earth, in the interior, are seven hollow spaces; they are called *pātālas*. In these, the world of serpents see due to the sun[-bright] light of the gems on the hoods of the great serpents.

The seven *pātālas* are [as follows]. Atala, Vitala, and the one beginning with *ni* [i.e., Nitala]. Below these is another called Gabhastimat. The next two are the ones beginning with *mahā* and *su*, [respectively, i.e., Mahātala and Sutala]. [The last one is] Pātāla [or Pātālatala].

~ COLORS IN THE PĀTĀLAS ~

(63^{a-b}) In the *pātālas* there are the [colors] black, white, red, yellow, gravelly, stony, and golden.

~ THE SERPENT SUPPORTING THE EARTH AND THE CAUSE OF EARTHQUAKES ~

(63^{b-d}) This serpent [Śeṣa], who on the underside supports the Earth, who is resting on the tortoise, who stepped with his foot across the Earth's surface, sometimes [becomes] one with his head bent down by the weight of the Earth, and then there is an earthquake. This is the view of the *saṃhitās*.

Śeṣa, one of the *avatārapuruṣas* mentioned in verse 21, supports the Earth from below. When the weight of the Earth causes his head to move, earthquakes occur. The *saṃhitās* mentioned here are treatises on divination of various kinds.

~ THE SEVEN WINDS ~

(64) [The wind called] Bhūvāyu abides 12 *yojanas* from [the surface of] the Earth. The clouds [exist] in it. After that is [the wind] called Āvaha. After that is the wind called Pravaha, which has a westward motion. After that are the Udvaha and Saṃvaha [winds]. Two other winds are the Parivaha and the Parāvaha.

The multitude of stars along with the planets move amidst these [winds] [pushed] by the Pravaha [wind].

This verse describes the seven cosmic winds. In the Indian astronomical tradition, it is considered that these winds are the cause of planetary motion, moving the planets and the stars.

In the *Siddhāntaśiromaṇi*, Bhūvāyu and Āvaha are considered the same wind, and Suvaha is inserted between Saṃvaha and Parivaha.¹⁷

~ THE TWO POLESTARS ~

(65) The two polestars are in the sky at the top and bottom of Meru. The circle of stars is rotating, being between the polestars. As if situated like

¹⁷ *Siddhāntaśiromaṇi*, *golādhyāya*, *madhyagativāsanādhikāra*, 1.

Planet	Geocentric distance in <i>yojanas</i>
Moon	51,566
Mercury	166,032
Venus	424,088
Sun	689,377
Mars	1,296,619
Jupiter	8,176,538
Saturn	20,319,071
The stars	41,362,658

Table 2.1: Geocentric distances of the planets

a piece of iron between two stones named loadstones, which are in the sky, the circle of stars does not fall down.

~ GEOCENTRIC DISTANCES OF THE PLANETS ~

(66–68) The Creator placed the disc of the Moon, which is an ornament in the form of a sphere of water, at 51,566 [*yojanas*] from the center of the Earth; Mercury at 166,032 [*yojanas* from the center of the Earth]; Venus, which consists of light, at 424,088 [*yojanas* from the center of the Earth]; the Sun at 689,377; Mars at 1,296,619 [*yojanas* from the center of the Earth]; Jupiter at 8,176,538 [*yojanas* from the center of the Earth]; Saturn at 20,319,071 [*yojanas* from the center of the Earth]; and the circle of the stars, which is evenly marked with invisible constellations beginning with Aśvinī and bound to the pair of polestars, in the sky far from [the orbits of] all [the planets] at 41,362,658 [*yojanas* from the center of the Earth].

As noted in the Introduction (see p. 22), planetary motion is described using epicycles in Indian astronomy. As such, the planets do not move on a perfect circle around the Earth. However, each planet has a mean distance to the Earth, and it is these distances that are given here by Jñānarāja. The geocentric distances of the planets as presented here are shown in Figure 2.1.

~ METHOD FOR FINDING THE GEOCENTRIC DISTANCES ~

(69–75) The demonstration by Bhāskara [II], Pṛthūdakasvāmin, and others is not given here in our *tantra*. I am presenting a [demonstration] that is effective in counteracting the opinions of adversaries, is the opinion of noble-minded people, and is very pleasing.

The time between the rising and the setting of the Moon on the local horizon is one's own "day"; it is established by means of a water clock. Whatever is [arrived at] in this case [as the *ghaṭikās*] in the "day" from the motion of the Moon by means of the method in the *tripraśnādhikāra*, that is the measure of the "day" for a person in the center of the Earth.

If *yojanas* corresponding to the radius of the Earth multiplied by two times [the motion of] the Moon are [arrived at] by means of the difference in *ghaṭikās* of the two [times], then what is [arrived at] by means of the *ghaṭikās* of one's own "day and night" [i.e., the period between one Moon-rise and the next]? By means of a proportion, the answer is the orbit in *yojanas* of the Moon. Alternatively, this is to be computed from a syzygy with the Sun.

If this orbit of the Moon is [arrived at] by means of the true velocity [of the Moon], then what [is arrived at] by means of the mean velocity? In this case, [the answer is] the mean [orbit]. The product of that and the revolutions of the Moon [in a *kalpa*] is the orbit of heaven. That [orbit of heaven] divided by the revolutions of a planet [in a *kalpa*] is [the planet's] own orbit.

The orbits [of the planets] multiplied by the radius and divided by the minutes of arc in the degrees of a revolution [i.e., 21600 minutes of arc] are the geocentric distances in *yojanas*.

The diameter [of a circle] is approximately the square root of [the result of] the division of the square of the circumference [of the circle] by 10. The accurate [value is found as follows]. The [trigonometric] radius multiplied by two [is the divisor when the 21600 minutes of arc] in the circle of stars [is the dividend], [all of which is multiplied by the circumference].

The total motion of a planet in a [*mahā*]*yuga* is 18,712,080,864,000 *yojanas*. The Earth has a circumference of 5,059 [*yojanas*].

Thus the geocentric distances in *yojanas* known through a good demonstration are given, as well as the measure of the circumference of the Earth agreed to by [both] demonstration and the *āgamas*.

Consider Figure 2.1. The small circle in the center is the Earth and the larger circle the apparent path of the Moon around the Earth in its daily rotation. The center of the Earth is *O* and the given location is *P*. The line *CPB* is the horizon at *P*, and the line *DOA* is a parallel line through the

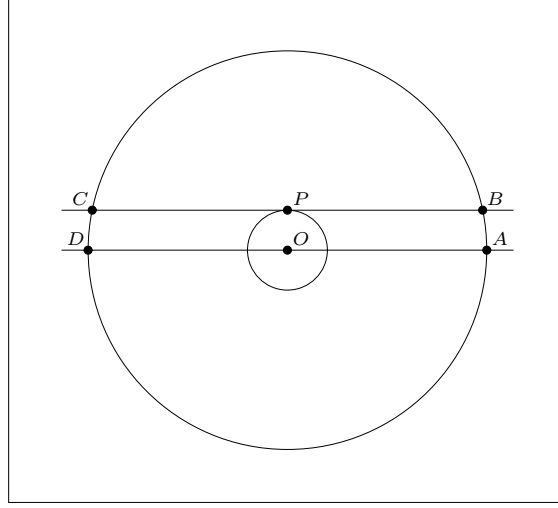


Figure 2.1: Finding the geocentric distance of the Moon

center of the Earth, at which point Jñānarāja imagines an “observer”.

For a person at P , the Moon rises when it is at the point B and sets when it is at the point C . Let us assume that this takes t *ghaṭikās* (for the the unit *ghaṭikā*, see the Introduction, p. 22). Now, if we compute the times for the rising and the setting of the Moon according to the methods given in this work, because the Earth is considered a point, the times will be valid for Jñānarāja’s imagined “observer” at the center of the Earth, but not for an observer displaced from the center at P . For Jñānarāja’s imagined “observer”, the Moon “rises” when it is at the point A and “sets” when it is at the point D . Clearly the time it takes for the Moon to travel from A to D is greater than t *ghaṭikās*. Let us say it is $t + \tau$ *ghaṭikās*.

Now, the extra distance traveled by the Moon from A to D is the arc AB and the arc CD . Each of these arcs is roughly equal to the distance OP , which is the radius of the Earth, as can be seen on the figure. Hence the two arcs are together roughly equal to two Earth radii. Let m be the circumference of circle $ABCD$ and σ the duration from one rising of the Moon to the next. Jñānarāja uses a simple proportion to relate the time τ for traversing the two arcs and the time σ for traversing the whole circle as follows:

$$\frac{\tau}{2 \times |OP|} = \frac{\sigma}{m}, \quad (2.5)$$

and thus

$$m = \frac{2 \times |OP| \times \sigma}{\tau}. \quad (2.6)$$

The circle $ABCD$ is equal to the size of the Moon’s true orbit at the given time, because the Moon is located at the distance of its orbital radius. The time between two successive observed Moonrises determines the true velocity of the Moon, whereas using the Moon’s mean velocity to calculate σ and τ gives us a value for m that represents the size of the mean orbit of the Moon.

The product of the Moon's orbit and the revolutions of the Moon in a *kalpa* is the orbit of heaven. This is because the cosmology of the *siddhāntas* assume that each planet travels the same number of *yojanas* in a *kalpa*, namely 18,712,080,864,000 *yojanas*,¹⁸ which is also the orbit of heaven.¹⁹ So, by dividing the orbit of heaven by the revolutions of a given planet, we can find the orbit of that planet.

To find the geocentric distance g of the planet, we note that g is the orbital radius of a circle of circumference c . Since $2 \times \pi \approx \frac{21600}{3438}$,²⁰ we have that

$$g \approx \frac{c}{\frac{21600}{3438}} = \frac{3438 \times c}{21600}. \quad (2.7)$$

Jñānarāja gives two methods for computing the diameter d of a circle from its circumference c . The first is equivalent to the expression

$$d = \sqrt{\frac{c^2}{10}}, \quad (2.8)$$

which is an approximation and based on $\pi \approx \sqrt{10}$. The second, which he uses to compute g , is equivalent to the expression

$$d = \frac{3438 \times c}{21600}, \quad (2.9)$$

which is based on $2 \times \pi \approx \frac{21600}{3438}$. Jñānarāja says that this latter method is exact, but it is in fact also approximate, because it also uses an approximate value of π . Taking $\pi = \sqrt{10}$ in cosmological computations is common; the approximation is also found in the mathematics of the Jain community of India.

The value given for the circumference of the Earth is 5,059 *yojanas*.

~ EXPLAINING COSMOLOGICAL DIFFERENCES ~

(76) The shapes, measures, and motions of the Earth, planets, and stars given by the followers of the *purāṇas*, which are ultimately true, are indeed for another *kalpa*. Now, [in this present *kalpa*,] the [shapes, and so on of the Earth, and so on] given in the treatises that give knowledge of time [i.e., *jyotiḥśāstra*] are to be thoroughly studied by the wise.

The contradictions between the cosmology of the *purāṇas* and the cosmology of the astronomical tradition are here explained by *kalpabheda* (see verse 19).

~ KNOWLEDGE OF THE COSMOS AS A MEANS TO LIBERATION ~

(77) He who knows the variegated body of the Cosmic Being that comprises

¹⁸The same value of the orbit of heaven is given in *Sūryasiddhānta* 12.90.

¹⁹See [71 . 556].

²⁰This will be discussed in greater detail in the *spāṣṭādhikāra*, the beginning of which deals with trigonometry.

everything and is spoken about by the ancient sages attains intimate union with the Supreme Being; thus is the meaning of the words of Vedavyāsa, [the compiler of the *purāṇas*].

~ THE WORLD AS A ŚIVALIṄGA ~

(78) Whose body-encircler [i.e., the lower part of a *śivaliṅga*] is the Earth with its oceans, whose ultimate [upward] staff [i.e., the upper, phallic part of a *śivaliṅga*] is [the mountain] Meru, whose base is the tortoise [i.e., one of the *avatārapuruṣas* supporting the Earth], for its bath the clouds which are moving abodes of water, and for its fruits and flowers for worship the stars, Moon, and planets, and for its waving of the sacred lamp the Sun, may that *jyotirliṅga* worshipped by Brahman be even within me.

A *śivaliṅga* (called *jyotirliṅga* in the verse) is a phallic symbol used to worship the deity Śiva. In the verse, the world is portrayed as a *śivaliṅga* worshipped by the creator-god Brahman. Note that the verse does not describe the tusk of the elephant-headed deity Gaṇeśa.

~ CONCLUDING VERSE ~

(79) [Thus] the form of the universe in the *golādhyāya* is explained in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 3

grahagaṇitādhyaṃya section 1 *madhyamādhikāra*

Mean motion

~ INVOCATION ~

(1) I salute Gaṇeśa, whose five lofty faces are the elephants of the quarters, in whose belly is the whole universe, whose crest-jewel is a necklace of thousands of mountains, who has the blue sky as his garment, who takes away the inner darkness, who is bearing the crescent Moon, whose beauty is resplendent like tens of millions of Suns, whose carrier is like a boar, and who is the greatest bestower of good.

Jñānarāja is here praising Gaṇeśa, the deity whom he worships, in a verse seeking to highlight Gaṇeśa as the supreme deity.

~ THE ASTRONOMICAL TIME PERIODS DEFINED ~

(2-3) Now, [the duration of the reign of] a *manu* is [measured] by 71 [*mahā*]*yugas*. There are 14 *manus* in a day of Brahman. [The duration of] 1,000 [*mahā*]*yugas* is [measured] by [the duration of] those [14 *manus*] increased by [the duration of] the *sandhis* [that each are] equal to the

years in a *kṛta*[*yuga*] [and are situated] at the three [types of] junctures. [Such 1,000 *mahāyugas* constitute] a day [of Brahman].

A [*mahā*]*yuga* is [measured] by 4,320,000 [*saura*] years. Its four parts, the first being the *kṛta*[*yuga*], span, respectively, 432,000 *saura* years multiplied by 4, 3, 2, and 1.

Indian astronomy operates with a number of world ages (*yugas*) of long duration, which are measured in *saura* years. A *saura* (literally, solar) year is what in modern terminology is called a sidereal year. It is the time that it takes for the Sun to return to the same position with respect to the fixed stars when viewed from the Earth. The beginning of a *saura* year occurs when the Sun enters the sign Aries. It should be noted here that the zodiac in Indian astronomy is sidereal (see Introduction, p. 22).

A *mahāyuga* (literally, great world age) is a period of 4,320,000 *saura* years. It is divided into four smaller *yugas*: a *kṛtayuga* of 1,728,000 *saura* years, a *tretāyuga* of 1,296,000 *saura* years, a *dvāparayuga* of 864,000 *saura* years, and a *kaliyuga* of 432,000 *saura* years. Notice that these *yugas* are, respectively, $\frac{4}{10}$, $\frac{3}{10}$, $\frac{2}{10}$, and $\frac{1}{10}$ of the duration of a *mahāyuga*. Of these four ages, the *kṛtayuga* is considered to be a golden age. As the ages progresses, they get worse (morality deteriorates, greed and other bad qualities become dominant, the life span of human beings decreases, and so on), and the *kaliyuga* is the worst of them all. According to the Indian tradition, we are currently in a *kaliyuga*.

The system of the *yugas* is not original to the Indian astronomical tradition, but has incorporated into it from the cosmology of the *purāṇas* (see Introduction, p. 23).

A *kalpa* is a day of the creator god Brahman. It consists of 1,000 *mahāyugas*, or 4,320,000,000 *saura* years. At the end of the *kalpa*, when Brahman's night begins, the universe is partially destroyed, and at the dawn of Brahman's next day, there is a new creation.

A *manu* is a mythical progenitor and ruler of the Earth. There are 14 *manus* during a *kalpa*, each reigning for a period of 71 *mahāyugas*. The three types of junctures (*sandhi*) mentioned in the verse are the time periods that occur before the reign of the first *manu* of the *kalpa*, between the reigns of two consecutive *manus*, and at the end of the reign of the last of them. There are thus altogether 15 such junctures, and each has the same duration as a *kṛtayuga*, i.e., $\frac{4}{10}$ of a *mahāyuga*, or 1,728,000 *saura* years.

The reigns of the 14 *manus* together span $14 \times 71 = 994$ *mahāyugas* and the 15 junctures span $15 \times \frac{4}{10} = 6$ *mahāyugas*. The sum of these durations gives us the total duration of Brahman's day, the *kalpa*.

As we shall see later in verses 18–24, the planets make a whole number of revolutions (a revolution of a planet is its journey around the Earth, from a given point with respect to the fixed stars to the same point) during a *mahāyuga*, but this is not the case with the apogees and nodes. However, during a *kalpa*, the planets, the apogees, and the nodes all make a whole number of revolutions. In other words, the *kalpa* corresponds to the Platonic idea of the Great Year, a period at the end of

which everything returns to the same positions they had at its beginning.

~ TIME ELAPSED SINCE THE COMMENCEMENT OF PLANETARY MOTION ~

(4-5) In this day of Brahman, 6 *manus*, 27 [*mahā*]*yugas*, 3 parts of a [*mahā*]*yuga*, and 3,179 [*saura*] years of the *kalī*[*yuga*] [i.e., the fourth part] had passed at the commencement of the *śaka* [era] of the good Śālivāhana.

[When] the [47,400 divine] years mentioned earlier multiplied by 360 [is] subtracted from what has elapsed of the day of Brahman, [we get the years] that have elapsed since [the commencement of] planetary motion. They are 1,955,883,179 at the commencement of the *śaka* [era]. [These 1,955,883,179 years] along with the [elapsed years] of the *śaka* [era] are the given years [i.e., the years from the commencement of planetary motion to the present].

Jñānarāja now proceeds to tell us how much of the present *kalpa* has elapsed. The *śaka* era, which is said to have been instituted by King Śālivāhana, began in 78 CE according to our calendar. At the commencement of the *śaka* era, Jñānarāja tells us, the reigns of 6 *manus*, as well as 27 *mahāyugas*, a *kṛtayuga*, a *tretāyuga*, a *dvāparayuga*, and 3,179 *saura* years of a *kaliyuga* of the seventh *manu* have elapsed. Note that we are currently in a *kaliyuga*.

The 6 *manus*, including their 7 corresponding junctures, spanned a period of

$$6 \times 71 \times 4,320,000 + 7 \times 1,728,000 = 1,852,416,000 \quad (3.1)$$

saura years.

The 27 *mahāyugas*, the *kṛtayuga*, the *tretāyuga*, and the *dvāparayuga* that have elapsed during the reign of the seventh *manu* until the beginning of our present *kaliyuga* spanned a period of

$$27 \times 4,320,000 + \frac{9}{10} \times 4,320,000 = 120,528,000 \quad (3.2)$$

saura years.

Finally, 3,179 *saura* years have elapsed from the beginning of the *kaliyuga* to the commencement of the *śaka* era, giving a total of

$$1,852,416,000 + 120,528,000 + 3,179 = 1,972,947,179 \quad (3.3)$$

saura years from the beginning of the *kalpa* to the commencement of the *śaka* era.

However, according to the *saṃvatsara*, the school of astronomy that Jñānarāja follows, planetary motion did not commence at the begin of the *kalpa*. Rather, as explained in the *golādhyāya*,¹ a

¹See 1.1.20.

period of 47,400 divine years, called *śṛṣṭikāla* (literally, time of creation), passed from the beginning of the *kalpa* until the commencement of planetary motion. A divine year is a year of the gods. According to the Indian tradition, such a year equals 360 *saura* years, so the 47,400 divine years equal

$$360 \times 47,400 = 17,064,000 \quad (3.4)$$

saura years. When this period is subtracted from the above result, we get the *saura* years that have elapsed between the commencement of planetary motion and the commencement of the *śaka* era, namely

$$1,972,947,179 - 17,064,000 = 1,955,883,179 \quad (3.5)$$

saura years, as stated in the verse.

After the 17,064,000 *saura* years of the *śṛṣṭikāla* have elapsed, all the planets, apogees, and nodes commence their motion starting from Aries 0°, the beginning of the sign Aries (see verse 6).

Why does the *saurapakṣa* postulate that a period of 17,064,000 *saura* years has elapsed between the beginning of the *kalpa* and the commencement of planetary motion? There is no reason for this to be found in the religious and mythological texts of India. In fact, the idea is a mathematical trick. By insisting that such a period elapsed before planetary motion commenced, one is ensured that a mean planetary conjunction occurs at the beginning of our present *kaliyuga*.² Note that other numbers than 17,064,000 can be found that fulfill this requirement as well, and it is not clear why this particular number was chosen.

Note that the *śṛṣṭikāla* prevents the *kalpa* from acting fully as a Great Year. At the end of the *kalpa*, when there is a partial destruction of the universe, the planets, the apogees, and the nodes will only have moved for 4,320,000,000 – 17,064,000 *saura* years, and will thus not be back at their original positions at Aries 0°.

~ PLANETARY POSITIONS AT THE COMMENCEMENT OF MOTION ~

(6) [When the longitudes of] the planets, apogees, and nodes computed for the beginning of a [given] *saura* year [are] diminished by the motion [of the planet, apogee, or node] in a year multiplied by the *saura* years elapsed [since the commencement of planetary motion], they are situated at the beginning of Aries.

What the verse is essentially saying is that when planetary motion began at the end of the *śṛṣṭikāla*, the position of each planet, each apogee, and each node was Aries 0°.

Let m be a positive integer. In the following we will use the mathematical notation that $a \equiv_m b$ means that a and b differ only by a multiple of m , i.e., that $a - b = k \times m$ for some integer k . For example, $737 \equiv_{360} 17$ since $737 - 17 = 2 \times 360$.

²See [71 . 609].

Suppose that exactly n *saura* years have elapsed since the commencement of planetary motion, and let v be the mean motion of a given planet during a *saura* year. During the n *saura* years of motion, the mean planet moved the angular distance $n \times v$ (measured in degrees), which thus, except for a multiple of 360° , equals $\bar{\lambda}$, the planet's mean longitude (i.e., the longitude of the mean planet) at that time. In other words, there is an integer k such that

$$n \times v = k \times 360^\circ + \bar{\lambda}, \quad (3.6)$$

or, equivalently,

$$\bar{\lambda} \equiv_{360} n \times v. \quad (3.7)$$

This tells us that $\bar{\lambda} - n \times v$ gives us the starting point of motion, i.e., the zero point on the ecliptic. What the verse further tells us is that the starting point is the same for all of the planets, the apogees, and the nodes, namely Aries 0° .

~ CRITICISM OF OTHER ASTRONOMICAL SCHOOLS ~

(7) **It has been said that the planets, being simultaneously in one place, commence their eastward motion at the beginning of Brahman's day. Those [who say this] are opposed to the *vedas*, [because the idea] differs from the opinion of Brahman, Sūrya, Candra, and others.**

The idea of the *śṛṣṭikāla*, used in the *saurapakṣa* to ensure a mean conjunction of the planets at the beginning of our *kalīyuga*, is not universally agreed upon in the Indian astronomical tradition. The *brāhmapakṣa*, the oldest of the schools of classical Indian astronomy, does not employ it, but rather has the planets, the apogees, and the nodes commence their motion right at the beginning of the *kalpa*. Here Jñānarāja attacks this opinion for being opposed to the opinion of divine personages recorded in the sacred texts.

The authorities whose opinions Jñānarāja appeals to here are the deities considered to be the narrators of the astronomical texts considered divinely and scientifically authoritative by Jñānarāja: the *Brahmasiddhānta*, the *Sūryasiddhānta*, the *Somasiddhānta*, and so on. These texts all belong to the *saurapakṣa*, and advocate the idea of the *śṛṣṭikāla*.

This verse together with the following two (verses 8–9) is cited in the *Siddhāntasārvabhauma* of Munīśvara.³

~ IMPORTANCE OF ADHERING TO AUTHORITATIVE TEACHINGS ~

(8) **The pure [teaching] that Brahman spoke to Nārada, Candra spoke to Śaunaka, the sage Vasiṣṭha spoke to Māṇḍavya, and Sūrya spoke to**

³See [98 . 1.19–20].

Maya is full of reasoning based on perception and traditional teachings. Whatever men do differently after abandoning this science, that ceases to produce correct results over time, because they are devoid of [proper] knowledge.

An astronomical model with errors in the parameters or elsewhere might prove fairly accurate around the time when it was established, but over long periods of time the errors will reveal themselves as predicted planetary positions and so on start to deviate more and more from what is observed. Jñānarāja maintains that such will be the case when men deviate from the science as taught by deities and sages, their teaching being not only based on the sacred tradition, but also full of sound reasoning.

The knowledge given by Brahman to Nārada, by Candra to Śaunaka, by Vasiṣṭha to Māṇḍavya, and by Sūrya to Maya is the contents of, respectively, the *Brahmasiddhānta*, the *Somasiddhānta*, the *Vasiṣṭhasiddhānta*, and the *Sūryasiddhānta*.⁴

This verse together with the previous verse and the following verse (verses 7 and 9) is cited in the *Siddhāntasārvabhauma* of Munīśvara.⁵ It is further found in the *Siddhāntatattvaviveka* of Kamalākara.⁶ Kamalākara does not attribute this verse to Jñānarāja or the *Siddhāntasundara*, and the last *pāda* is different. The first half of the verse is cited by Dikshit from the *Siddhāntatattvaviveka*,⁷ but due to Jñānarāja not being mentioned, Dikshit erroneously attributes it to Kamalākara.

~ HOW TO DEAL WITH A DEFECT FOUND IN THE TEACHINGS OF THE SAGES ~

(9) If somewhere something different from what is taught by the sages is perceived by men, then that alone is to be corrected. Everything is not to be done differently.

Jñānarāja now opens up the possibility that some defect might be found in the teachings of the ancient sages. If that should happen, one is not to reject the teachings entirely, though, but rather correct the defect while maintaining the overall system and theory.

This verse together with the two previous verses (verses 7–8) are cited in the *Siddhāntasārvabhauma* of Munīśvara.⁸

⁴See introduction, p. 35.

⁵See [98 . 1.19–20].

⁶See [24 . 19].

⁷[22 . 2.46–47].

⁸See [98 . 1.19–20].

~ HOW TO DEAL WITH A DEFECT FOUND IN THE TEACHINGS OF THE SAGES ~

(10) **Just as [when] no strength is found somewhere in the *mantras* enunciated in the *vedas*, one should perform their *puraścaraṇa*. Everything is not to be done differently.**

A *puraścaraṇa* is a procedure for making a *mantra* (a sacred verse, phrase, or mystical syllable, usually in Sanskrit, used for spiritual practice) effective.⁹ The main part is repetition of a *mantra*, but it also includes other things, such as fire offerings and feeding of *brāhmaṇas* (the class of priests and intellectuals in the Hindu tradition). It is a practice from the tradition of the *tantras* (not to be confused with the astronomical treatises known as *tantras*, the *tantras* mentioned here are esoteric texts outlining various spiritual practices; see also commentary on 1.1.2) known in both Hindu and Buddhist contexts, but the *mantras* employed in the procedure can also be *mantras* from the *vedas*.¹⁰ Around the time of Jñānarāja, the practice of *puraścaraṇa* gravitated into the ritual world of the *vedas*.

Jñānarāja's point here is that when a *mantra* from the *vedas* is seen to lack strength or energy (*vīrya*), i.e., if it is seen to be ineffective for some reason, it is not rejected. Rather, a *puraścaraṇa* of the *mantra* is carried out in order to make it effective. A *puraścaraṇa* can, for example, be carried out to infuse *mantras* from the *vedas* with power via methods from the *tantras*. In this example, *mantras* from the *vedas* are considered not to be independently powerful, but require charging through Tantric practices. So, similarly, if a defect is found somewhere in the science of astronomy, one ought not to discard the whole science, but rather try to correct the defect.

~ ACCEPTANCE OF THE TEACHINGS OF THE SAGES ~

(11) **The knowledge which is the opinion of the sages, which since ancient times has constantly been perceived as agreeing with observation, and which is to be understood through *vāsanās*, that is agreed to by us.**

This verse paraphrases Jñānarāja's approach to astronomy. The science that he subscribes to is one that comes through the authority of ancient sages, but beyond being merely the opinion of authoritative figures, Jñānarāja holds that it agrees with observation and can be understood through various methods. As such, this knowledge is not mystical.

⁹I am indebted to Gudrun Bühnemann, Christopher Minkowski, and Frederick Smith for explaining the idea of the *puraścaraṇa* via personal communications.

¹⁰For the *puraścaraṇa* in the context of the *tantras*, see [7 . 301–305] and [8].

(12–17) There are 1,593,336 intercalary months and 25,082,252 omitted *tithis* in a [*mahā*]yuga. The number of lunar months [during a given period of time] is the difference between the revolutions of the sun and the moon [in that same period]. During a [*mahā*]yuga, [the number of lunar months] is given by 53,433,336 according to the sages. There are 1,555,200,000 *saura* days in a [*mahā*]yuga. The number of *tithis* is 1,603,000,080. In a [*mahā*]-yuga there are 1,577,917,828 civil days and 1,582,237,828 sidereal days.

The knowledgable ones always say that the omitted *tithis* [in a *mahā*-yuga] are the difference between the civil days and the *tithis*, and that the *tithis* in the intercalary months are the difference between the number of *saura* days and the number of *tithis*. The number of days of a planet [i.e., the time between two consecutive risings of the planet] [in a *mahāyuga*] is measured by the revolutions of the stars diminished by the revolutions [of the planet in a *mahāyuga*]. In this case, because it is widely known, the method is not given; it is [arrived at] by intellect and one's own understanding alone.

In our modern calendar we insert a leap year every four years in order to keep the calendar year and the astronomical year synchronized. This is necessary because astronomical events do not repeat after an integer number of days, and hence a drift occurs between the event and the calendar day on which it occurs. For example, the season of spring would commence at different dates over time. The Indian tradition inserts an intercalary month at times for the same purpose, though this procedure is not done after as simple a scheme as in our calendar.

A lunar month is the time between one conjunction of the Sun and the Moon and the next. There are 30 *tithis* in a lunar month, the first ending when the Moon has gained 12° over the Sun in longitude, the second when the Moon has gained a further 12°, and so on. Since the velocities of the Sun and the Moon vary, the duration of a *tithi* is not constant. The duration of a *tithi* varies between about 22 hours and about 26 hours.

There are 12 *saura* months of the same duration in a *saura* year, and 30 *saura* days, again of the same duration, in a *saura* month.

In the Indian astronomical tradition, a civil day is either time between two consecutive sunrises or between two consecutive midnights. Jñānarāja follows a midnight system, and hence the latter is the case in the *Siddhāntasundara*. A civil day is roughly 24 hours.

When a *tithi* occurs entirely between one midnight and the next (or between one sunrise and the next, depending on which astronomical school one follows), it is called omitted.

The units in a *mahāyuga* presented here by Jñānarāja are given in Table 3.1 together with the

Unit	Symbol	Number in a <i>kalpa</i>
Intercalary months	A	1,593,336
Omitted <i>tithis</i>	U	25,082,252
Lunar months	M	53,433,336
<i>Saura</i> days	S	1,555,200,000
<i>Tithis</i>	T	1,603,000,080
Civil days	C	1,577,917,828
Sidereal days		1,582,237,828

Table 3.1: Astronomical units given in verses 12–17

symbols that we will use to designate them in the following.¹¹ The units are based on the number of revolutions of the planets that he will give subsequently in verses 18–24.

Let us assume that two planets, P_1 and P_2 , make r_1 and r_2 revolutions, respectively, during a given period of time, and that P_1 is the faster of the two. If they are at the same position at the beginning of the period, the faster planet will catch up with the other planet $r_1 - r_2$ times during the period.

We can prove this result mathematically as follows. Suppose that the planet P_1 moves with the velocity $v+u$ (measured in degrees per unit time), making r_1 revolutions in a period of time of length t . Suppose similarly that the planet P_2 moves with the velocity v , making r_2 revolutions in the same period of time. Finally, suppose that the two planets are at the same position at the beginning of the period. Then $t \times (v+u) = 360 \times r_1$ and $t \times v = 360 \times r_2$, and therefore $t \times u = 360 \times (r_1 - r_2)$. In order for the two planets to have the same position at a time τ with $0 \leq \tau \leq t$, we must have $\tau \times (v+u) \equiv_{360} \tau \times v$, i.e., that there is a positive integer k , so that $\tau \times u = 360 \times k$. This means that if n is chosen so that $360 \times n \leq t \times u < 360 \times (n+1)$, P_1 catches up with P_2 a total of n times during the given period of time. But $t \times u = 360 \times (r_1 - r_2)$, so $n \leq r_1 - r_2 < n+1$, and n is therefore the integer part of $r_1 - r_2$. This completes the proof.

As a lunar month is the period from one conjunction of the Sun and the Moon to the next, we can use this result to find the number of lunar months in a *mahāyuga*. According to verse 18 below, the Sun and the Moon make, respectively, 4,320,000 and 57,753,336 revolutions during a *mahāyuga*. Hence there are

$$57,753,336 - 4,320,000 = 53,433,336 \quad (3.8)$$

lunar months in a *mahāyuga*, as stated in the verse.

Since a *saura* year is one sidereal revolution of the Sun starting at Aries 0° and a *mahāyuga* consists of 4,320,000 revolutions of the Sun, there are 4,320,000 *saura* years in a *mahāyuga*. A *saura* year comprises 12 *saura* months, each of which, in turn, comprises 30 *saura* days. Hence there are

$$30 \times 12 \times 4,320,000 = 1,555,200,000 \quad (3.9)$$

saura days in a *mahāyuga*.

¹¹The symbols are the same as those used by Pingree in [71].

Since there are 53,433,336 lunar months in a *mahāyuga*, there are $30 \times 53,433,336 = 1,603,000,080$ *tithis* in a *mahāyuga*.

The number of civil days is found as the revolutions of the stars in a *mahāyuga* diminished by the revolutions of the Sun in a *mahāyuga*. The revolutions of the stars in a *mahāyuga* is, of course, the number of sidereal days in a *mahāyuga*.

The omitted *tithis* are the excess of *tithis* compared to civil days in a *mahāyuga*, which is $1,603,000,080 - 1,577,917,828 = 25,082,252$.

We can find the number of *tithis* in the intercalary months in a *mahāyuga* as the difference between the *tithis* in a *mahāyuga* and the *saura* days in a *mahāyuga*. These are $1,603,000,080 - 1,555,200,000 = 47,800,080$. The number of intercalary months can then be found as $\frac{47,800,080}{30} = 1,593,336$.

Civil days are determined by the Sun's progress around the Earth. We can define days of other planets in precisely the same way. If we do so for a given planet, the number of days of that planet in a *mahāyuga* are found exactly like the number of civil days in a *mahāyuga*; we just use the revolutions of that planet rather than the revolutions of the Sun.

~ REVOLUTIONS OF THE PLANETS, THE APOGEES, AND THE NODES ~

(18–24) In a [*mahā*]*yuga* there are 4,320,000 revolutions of the Sun, Mercury and Venus. The revolutions of the Moon are given by the wise as 57,753,336. The number of revolutions of Mars in a [*mahā*]*yuga* is 2,296,832. The revolutions of Mercury's *śīghra* are 17,937,060. The number of revolutions of Jupiter is considered to be 364,220. The revolutions of Venus' *śīghra* in a [*mahā*]*yuga* is 7,022,376. The number of revolutions of Saturn is 146,568. The number of revolutions of the lunar apogee is 488,203. [All of the these move] with an eastward motion in the sky. In the case of the moon's node, [known as] Rāhu, the revolutions are understood to be 232,238 in the opposite direction. These [numbers] multiplied by 1,000 give [the revolutions] during a *kalpa*.

Now, the revolutions of the sun's *manda* apogee in a *kalpa* are 387. Beginning with Mars, [the revolutions] produced by the *manda* apogees [of the star-planets] are 204, 368, 900, 535, and 39.

In a *kalpa* [the revolutions] of the nodes, which are moving in the opposite direction, are, beginning with Mars, 214, 488, 174, 903, and 662.

These verses give the number of revolutions of each planet, each apogee, and each node during either a *mahāyuga* or a *kalpa*.

Body	Revolutions in a <i>mahāyuga</i>	Revolutions in a <i>kalpa</i>
the Sun <i>manda</i> apogee	4,320,000	4,320,000,000 387
the Moon <i>manda</i> apogee node	57,753,336 488,203 −232,238	57,753,336,000 488,203,000
Mars <i>manda</i> apogee node	2,296,832	2,296,832,000 204 −214
Mercury <i>śighra</i> apogee <i>manda</i> apogee node	4,320,000 17,937,060	4,320,000,000 17,937,060,000 368 −488
Jupiter <i>manda</i> apogee node	364,220	364,220,000 900 −174
Venus <i>śighra</i> apogee <i>manda</i> apogee node	4,320,000 7,022,376	4,320,000,000 7,022,376,000 535 −903
Saturn <i>manda</i> apogee node	146,568	146,568,000 39 −662

Table 3.2: Revolutions of the planets, apogees, and nodes

When authors of Indian astronomical texts say “starting from Mars”, the order is understood to be Mars, Mercury, Jupiter, Venus, and Saturn. This is the order of the weekdays, Tuesday being the day of Mars, Wednesday the day of Mercury, Thursday the day of Jupiter, Friday the day of Venus, and Saturday the day of Saturn. Sunday is the day of the Sun, and Monday the day of the Moon.

Now, the number of revolutions given here are the revolutions of the mean planets. The mean planet is not something found in reality, but is a construct used in the astronomical model. Each planet moves with variable speed around the Earth, but each planet also has a average velocity. Assume that there is a body moving with this constant velocity around the Earth along a perfect circle and that the body and the actual planet were at the same position when planetary motion began. Then this body is the mean planet corresponding to the planet in question.

The planetary theory of Indian astronomy will be explained in the next chapter (though see Introduction, p. 22). For now it suffices to say that each of the star-planets has two epicycles, each with an apogee. These two epicycles are called *manda* (slow) and *śighra* (fast). We can think of the *manda* epicycle as accounting for the fact that the planets do not move around the Earth in perfect circles, and the *śighra* epicycle as accounting for the fact that the Earth orbits the Sun rather than the Sun orbiting the Earth.

Table 3.2 shows the revolutions as given by Jñānarāja. They are identical with those given in

the *Sūryasiddhānta*.¹²

~ REVOLUTIONS BASED ON BOTH AUTHORITY AND A METHOD ~

(25) These are the very revolutions agreed upon in the *tantras* [treatises] [composed/spoken] by Brahman, Sūrya, Candra, Vasiṣṭha, Pulastya, and so on.

Here [in this work] I will now present a method that is pure, easy, unprecedented, and that provides understanding of the computation of the revolutions.

Dikshit notes that the revolutions given in the *Sūryasiddhānta*, the *Somasiddhānta*, the *Vasiṣṭha-siddhānta*, the *Romakasiddhānta*, and the *Brahmasiddhānta* (the astronomical treatises spoken by Sūrya, Candra, Vasiṣṭha, Viṣṇu, and Brahman, respectively) are identical and lists them in a table.¹³ With the exception of the revolutions of the node of Saturn, which Dikshit gives as 60, the values agree with those given by Jñānarāja. However, the 60 revolutions given by Dikshit for the node of Saturn may be a misprint, as the *Sūryasiddhānta* gives 662 revolutions like Jñānarāja.¹⁴

As has been noted, Jñānarāja is concerned with providing demonstrations that establish the validity of the divine knowledge that he is presenting. In keeping with that concern, a method by which the revolutions can be found through observation is given in the following.

~ DETERMINING THE EAST-WEST AND NORTH-SOUTH LINES ~

(26) The shadow of a gnomon that is straight and positioned on ground that has been made even by means of water [falls along the] south-north [line] at [the time of] the *ghaṭikās* of midday. The east and west directions are produced from the tail and head of [a figure in the shape of] a fish produced from it [the north-south line].

The construction described is straightforward. It is based on the fact that at noon, i.e., when the Sun is on the local meridian (i.e., the great circle connecting the north and the south poles and passing through the local zenith), the shadow cast by a gnomon will be aligned along the north-south line.

On Figure 3.1, *G* is the gnomon and *A* is the tip of the shadow cast by the gnomon at noon. The line *GA* is then the north-south line. Drawing two intersecting circles with the same radius

¹²See [71 . 608, table VIII.1; 609, table VIII.5] for tables of the revolutions according to the *Sūryasiddhānta*.

¹³See [22 . 2.27–28].

¹⁴*Sūryasiddhānta* 1.44. See also [71 . 608, 609, table VIII.5].

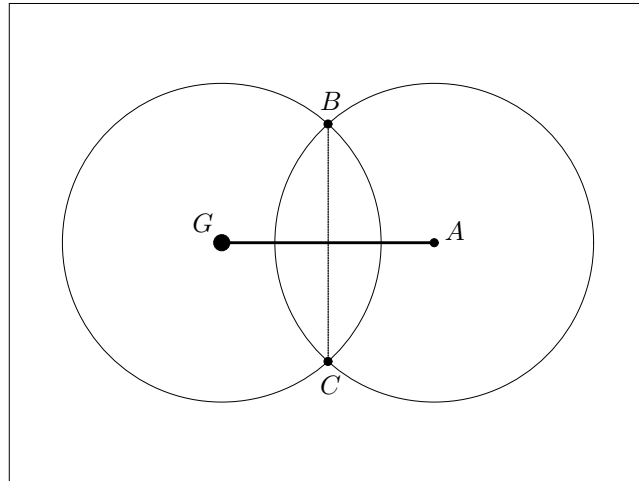


Figure 3.1: Determining the east-west and north-south lines

centered around G and A , respectively, let B and C be the two points of intersection between the circles. The line BC is then the east-west line. We have now determined the cardinal directions. The intersection of the two circles, which has the appearance of a fish, is called a “fish figure” in Indian astronomy. So, here a fish figure is used to determine the east-west line.

Jñānarāja does not directly address the question of how to determine when precisely it is noon, but by expressing “noon” as “the *ghaṭikās* of midday,” he hints that this is to be done by keeping track of time. If we know how many *ghaṭikās* there are between noon and (presumably) sunrise on the day in question, we can use a water clock to determine when it is noon.

This verse is given again later in the text (2.3.2).

~ DETERMINING THE SUN’S DECLINATION USING A SIGHTING TUBE ~

(27–29^a) **On the south-north [line] one should place the bottom edge of a post that is made from beautiful wood, [so that the post] is perfectly perpendicular and very straight.**

[First,] having fixed a peg on the upper part [of the post] and a flexible sighting tube on the peg [so that it falls along the] south-north [line], then, observing the Sun with that [sighting tube], determining the number of degrees of the altitude [of the Sun] from an instrument such as the quadrant, and subtracting [this number] from 90 [degrees], the degrees of the zenith distance [of the Sun] is the result. The difference or sum of that [zenith distance] and one’s own latitude, when the directions are the same and different, respectively, are the degrees of the declination [of the Sun].

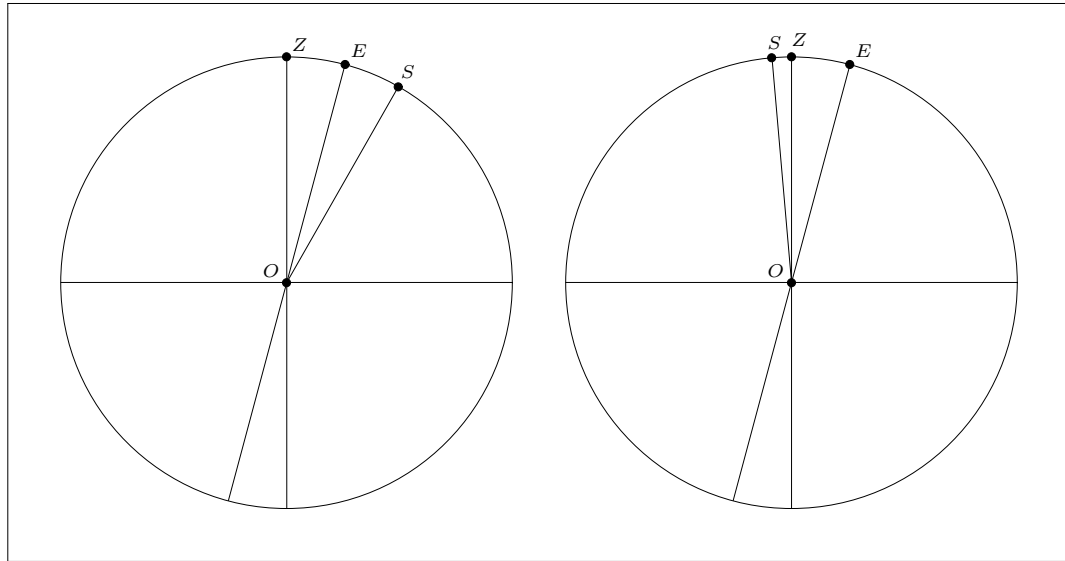


Figure 3.2: Computing the declination of the Sun from its zenith distance

The setting up of the sighting tube is clear from the verse. When the sighting tube is aligned with the north-south line, it can be used to observe the Sun when it is on the meridian. However, looking directly at the Sun through the sighting tube could damage the eyes of the observer, so perhaps the intended procedure is let sunshine pass through the sighting tube onto the surface of water in a vessel.

A quadrant (*turyayantra*, or simply *turya*) is an astronomical instrument used to measure the altitude of the Sun, i.e., the angular distance of the Sun above the horizon.¹⁵ Presumably, when the sighting tube points to the Sun, its orientation is used to determine the altitude of the Sun via the quadrant.

Let α be the altitude of the Sun. The Sun's "zenith distance" z is its angular distance from the zenith, which is 90° above the horizon, so $z = 90^\circ - \alpha$. The local latitude ϕ equals the angular distance of the zenith above the celestial equator, while the Sun's declination δ represents its own angular distance from the equator. Thus δ is given by combining z and ϕ , as described below.

This is illustrated in Figure 3.2. In both the analemmas of the figure the circle is the meridian, the horizontal line the local horizon, the vertical line the prime vertical, and the oblique line through the entire the equator. In both cases, the Sun, being the point S , is on the meridian. The point Z is the local zenith, and the point E is the intersection between the celestial equator and the local meridian. The point O is the center of the Earth.

In the first case, the Sun's zenith distance is the angle SOZ , and the local latitude is the angle ZOE . It is clear that the Sun's declination, δ , is

$$\delta = \angle SOE = \angle SOZ - \angle ZOE = z - \phi, \quad (3.10)$$

¹⁵ [31 . 205–206].

i.e., the Sun's zenith distance diminished by the local latitude. In the second case, we similarly have that

$$\delta = \angle SOE = \angle SOZ + \angle ZOE = z + \phi. \quad (3.11)$$

In this way the declination of the Sun can be found from its zenith distance and the local latitude.

~ FINDING THE SUN'S TROPICAL LONGITUDE ~

(29^{b-d}) **[When] the Sine of that [declination] is divided by the Sine of 24 [degrees] and multiplied by the Sine of 90 [degrees], the arc [corresponding] to that [resulting quantity] is the degrees of the arc of the Sun [measured from the vernal equinox, i.e., the Sun's tropical longitude] on that day.**

At the beginning of the night, after observing a star, one should fix its [the Sun's] position.

The first part of the verse gives a formula for computing the tropical longitude of the Sun (i.e., the longitude of the Sun measured with respect to the vernal equinox, which is the intersection between the ecliptic and the celestial equator at which the Sun crosses from the southern to the northern hemisphere) from its declination and the obliquity of the ecliptic. The formula involves the sine function, which will be properly introduced by Jñānarāja in the beginning of the next chapter. For now it suffices to say that the Indian tradition operates with a sine function with a non-unity trigonometrical radius. If α is any angle, we will denote the Indian sine of α by $\text{Sin}(\alpha)$. This equals $R \times \sin(\alpha)$, where R is the trigonometrical radius (Jñānarāja uses $R = 3438$; for more information, see the commentary on 2.2.2–5). When speaking of an Indian sine, we will write “Sine” rather than “sine”.

The obliquity of the ecliptic is the angle between the ecliptic and the celestial equator. It is taken to be 24° in the Indian tradition, and is what the 24° of the verse refers to. It is denoted by ε in the following.

If λ^* is the tropical longitude of the Sun and δ the declination of the Sun, the formula given can be written as

$$\text{Sin}(\lambda^*) = \frac{R \times \text{Sin}(\delta)}{\text{Sin}(\varepsilon)}. \quad (3.12)$$

This is, of course, simply the formula known as the “method of declinations”, i.e., $\text{Sin}(\delta) = \frac{\text{Sin}(\lambda^*) \times \text{Sin}(\varepsilon)}{R}$, by which the declination of the Sun can be found from its tropical longitude and the obliquity of the ecliptic (i.e., the angle between the ecliptic and the celestial equator).

The idea of the last part of the verse seems to be as follows. At sunset, when the sun is setting on the western horizon, one should observe what star is rising in the east. The Sun will be 180° from that star, so the Sun's sidereal longitude can be determined in this way.

~ DETERMINING THE LONGITUDE OF THE SOLAR APOGEE ~

(30) In this way, having first observed the precessional [longitude of the] true Sun [on a given day], next [the same procedure is to be followed] on another day. The true motion [of the Sun between the two days] is the difference between the two [longitudes of] the Sun. As much as the [longitude of] the sun is when that [true motion] is at a minumum, [the longitude of] its apogee is equal to that.

By precessional (*sāyana*) longitude is meant the Sun's longitude corrected for precession, i.e., its tropical longitude.

If we observe the Sun at noon on two consecutive days, we get two tropical longitudes. The difference between these is the angular distance traveled by the Sun between noon on the first day and noon on the second day. Continuing this process, a table of daily velocities of the Sun is produced. On the day that the Sun's velocity is at its minimum, it is understood that the Sun is at its apogee, i.e., it is the furthest from the Earth that it gets.¹⁶ In other words, the longitude of the solar apogee can be found as the longitude of the Sun when its minimum daily velocity is attained.

~ TO FIND THE MEAN MOTION, THE MEAN LONGITUDE, AND THE EQUATION ~

(31–32) The mean motion [of the Sun] is half of the sum of the smallest and the greatest true motions.

When the greatest motion occurs, then [the longitude of] the mean Sun is equal to the true [longitude].

Having determined that [longitude of the mean Sun] in signs and so on, then each day one should make the mean [Sun] move with the mean velocity according to the interval of time [elapsed from the time corresponding to the known mean longitude].

The equation [of the Sun] is the difference between its mean and true [longitudes].

The mean Sun is a theoretical construct forming part of the model of solar motion. It moves with constant velocity on a circle with the Earth as its center.

Let v_1 and v_2 be the maximum and minimum velocities of the Sun, respectively, and let $\bar{v}$ be the mean velocity of the Sun. Jñānarāja takes the mean velocity to be the average of the maximum

¹⁶For the model governing solar motion and the reason for the solar velocity being at its minimum when the Sun is at its apogee, see the next section on true motion.

velocity and the minimum velocity:

$$\bar{v} = \frac{v_1 + v_2}{2}. \quad (3.13)$$

We saw before that when the Sun travels with its minimum velocity, it is at its apogee. Similarly, when it travels with its maximum velocity, it is at its perigee (the point opposite, i.e., 180° from, the apogee). At both the apogee and the perigee (Jñānarāja only specifies the perigee indirectly by saying that the solar velocity is maximal), the Sun's mean longitude is equal to its true longitude. As we know the true longitude, we now have a point in time where the Sun's mean longitude is known. Let this longitude be $\bar{\lambda}$.

Starting with this point in time, we can now compute the position of the mean Sun at any given time. The mean Sun moves with the constant velocity $\bar{v}$, so if a period of time of length t has elapsed since the point in time at which we knew the Sun's mean longitude, the mean longitude after this period of time has elapsed is $\bar{\lambda} + t \times \bar{v}$.

Knowing both the true and the mean longitude of the Sun at a given time, we can find the equation, which is the difference between the two (this will be discussed in greater detail in the next section).

~ TO FIND THE GREATEST EQUATION AND THE EPICYCLICAL RADIUS ~

(33) **Wherever there is equality of the mean and true velocities, [there] is the greatest equation.**

It is to be understood that the radius of the epicycle is equal to the Sine of that [greatest equation].

The greatest equation is the greatest possible angular distance between the true planet and the mean planet. It occurs when the Sun is traveling with its mean velocity and is roughly equal to the radius of the solar epicycle.

~ TO FIND THE NUMBER OF REVOLUTIONS IN A KALPA ~

(34) **In this way, as great as the [longitude of] the Sun is in signs, degrees, and so on, so great is it due to the [passing of civil] days and their parts [such as *ghaṭikās*], [these elapsed days being] referred to as “star-eaten.”**

If one revolution is achieved by means of [a certain number of] these [civil days], then [how many revolutions] are achieved by means of the civil days in a *kalpa*? [It is explained] by the wise that those [revolutions in the result] are the revolutions [of the Sun] in a *kalpa* computed thus from a proportion.

The position of the Sun changes with time, elapsed time being called “star-eaten”, though I am not sure of the exact interpretation of this.

We can find the time it takes for the Sun to make one revolution. Say that this takes a civil days. Let C be the number of civil days in a *kalpa*. Then

$$\frac{1}{a} = \frac{r}{C}, \quad (3.14)$$

where r is the number of revolutions of the Sun in a *kalpa*. In this way, the number of solar revolutions in a *kalpa* can be determined by means of a proportion.

~ TO FIND THE MERIDIAN ECLIPTIC POINT WHEN THE MOON IS ON THE MERIDIAN ~

(35–36^{a-b}) **Having observed the Moon when it is on the meridian with a quadrant as explained earlier, it is to be understood that its declination is corrected for the lunar latitude.**

Regarding the corrected *ghaṭikās* as the lapsed *ghaṭikās* of the night at that time by means of an instrument, the accurate [longitude of the] meridian ecliptic point is to be computed from [the longitude of] the Sun by means of the rising times at Laṅkā using the method given subsequently.

It is said by the ancients that the moon with the visibility correction applied is equal to that [longitude of the meridian ecliptic point].

The declination of the Moon is the angular distance between the celestial equator and the Moon’s position on the ecliptic. However, the Moon is not on the ecliptic, but rather on its own inclined orbit. The angular distance between the ecliptic and the Moon’s position on its inclined orbit is called the lunar latitude. When the Moon is observed in the sky, what is seen is its actual position on its inclined orbit. Hence, as is stated, the Moon’s declination is corrected for the lunar latitude; its angular distance to the celestial equator is the combination of its declination and the lunar latitude.

If we know how many *ghaṭikās* has elapsed of the night when the Moon is seen on the meridian, for example by measuring the time with a waterclock, we can compute the longitude of the Sun at that time, and from that the longitude of the meridian ecliptic point (the intersection of the meridian and the ecliptic) can be found by means of the rising times of the signs (given by Jñānarāja in 2.2.39–40).

When the Moon is seen on the meridian, its position with corrections applied is that of the longitude of the meridian ecliptic point.

~ TO FIND THE LUNAR LATITUDE ~

(36^{cd}) **The latitude of the moon [when on the meridian] is the difference between the corrected declination [of the Moon] and the declination of the**

meridian ecliptic point.

The declination of a point is its angular distance to the ecliptic. The meridian ecliptic point is, of course, on the ecliptic, but the Moon is not. The Moon is on its own inclined orbit. The angular distance between the Moon and the ecliptic is called the lunar latitude. Jñānarāja notes that in the given situation, the lunar latitude can be found as the difference between the declinations of the meridian ecliptic point and the corrected declination of the Moon (corrected in the sense that lunar latitude and so on has been applied). This is correct if the meridian ecliptic point is considered to coincide with the nonagesimal, i.e., the point on the ecliptic between the ascendant and the descendant (the ascendant is the point on the horizon where the ecliptic is rising at a given time, and the descendant is similarly the point where it sets at that time). However, as is most often the case, these two points do not coincide, in which case the declination of the meridian ecliptic point and the corrected declination of the Moon have slightly different directions than the lunar latitude, and the formula is thus only approximately correct.

~ TO FIND THE LONGITUDE AND THE VELOCITY OF THE ASCENDING NODE ~

(37) **Whenever the southern latitude vanishes, [the longitude of] the Moon subtracted from a rotation is [the longitude of] the [ascending] lunar node.**

Having again [at another time] determined [the longitude of] that node, its velocity can be computed from the difference in time [between the two observations].

What is meant here is that at the point in time when the southern latitude vanishes, the latitude becoming 0° , the Moon crosses the ecliptic moving from the southern hemisphere to the northern hemisphere. There are two intersections between the inclined orbit of the Moon and the ecliptic, both of which are called nodes. The node at which the Moon crosses to ecliptic into the northern hemisphere is called the ascending node, the other the descending node. If we know the longitude of the Moon when it is at the ascending node, we can find the longitude of the ascending node by subtracting the longitude of the Moon from a rotation, i.e., 360° . The reason for the subtraction is that the node moves in the opposite direction of the Moon.

If this procedure is carried out twice, we can find the velocity of the ascending node.

~ TO FIND THE REVOLUTIONS OF THE MOON IN A MAHĀYUGA ~

(38) **The *manda* apogee of the Moon is to be found like the apogee of the Sun, and likewise its [the Moon's] [mean] motion. The revolutions [of the Moon] in a *mahāyuga* or a *kalpa* is to be computed by means of this**

[motion].

Following the same procedure as for the Sun, the longitude of the *manda* apogee of the Moon can be found, and from the mean velocity of the Moon. The number of revolutions of the Moon in a *mahāyuga* or in a *kalpa* can then be found from that mean velocity.

~ TO FIND THE REVOLUTIONS OF A STAR-PLANET IN A KALPA ~

(39) **Going ahead as before, the number of days in one revolution of a [star-]planet from the beginning of its retrogradation [is to be found through observation]. [Then] one should compute half of the sum of the maximum and the minimum of that. [Finally,] one should compute [the star-planet's] revolutions in a *kalpa* by means of that [quantity].**

The normal direction of a planet is eastward. The Sun and the Moon always move eastward, but the five star-planets occasionally change their direction and go westward for some time. A planet that is traveling eastward is said to be in prograde motion. A planet that is traveling westward is said to be in retrograde motion. During prograde motion, the planet's longitude steadily increases, whereas it steadily decreases during retrograde motion.

When a planet is about to change its direction, it appears to stand still in the sky for a period of time. When an eastward-moving planet stands still in the sky before moving westward, it is said to be at its first station. Similarly, when a westward-moving planet stands still before moving eastward, it is said to be at its second station.

Through observation, one can find the number of days in a revolution of star-planet from when it commenced its retrograde motion. Repeating this over time, one can find the mean velocity of the planet by taking the average of the largest and the smallest number of days found. In this way, the revolutions of the star-planet in a *kalpa* can be found.

~ EFFECTS OF THE MANDA AND ŚĪGHRA EQUATIONS ~

(40–41) **The combination of [the effects of] the *manda* and *śīghra* equations is always the difference between the [star-]planet as established by observation and the mean [star-planet]. When [this combination] is corrected by the reverse of the *śīghra* equation, only the *manda* equation remains.**

Even though there is no [*śīghra*] equation when [the longitude of] a [star-]planet is equal to [the longitude of] its own *śīghra* perigee or apogee, the true [longitude of the star-]planet is not equal to the mean [longitude in this case]. Therefore the *manda* apogee of the planet [contributes] a

little bit else [to the planet's equation].

A star-planet has two epicycles. The difference between the mean planet and the observed planet is precisely the effect of these two epicycles. If the effect from the *śīghra* epicycle is removed, only the effect from the *manda* epicycle remains. Note, however, that removing the effect of the *śīghra* epicycle is generally not nearly as easy as Jñānarāja makes it out to be here.

The reason that the mean and true planets do not coincide even when there is no *śīghra* equation is that the *manda* epicycle also has an effect, albeit smaller than that of the *śīghra* epicycle.

~ THE MANDA-CORRECTED PLANET ~

(42) There is no *śīghra* equation in the case of planets [whose longitudes] are equal to their own *śīghra* perigees or apogees. In that case, the true [planet] is the *manda*-corrected [planet], and the difference between that [manda-corrected planet] and the mean [planet] is the *manda* [equation].

When the mean planet is corrected by the *manda* equation, it is called the *manda*-corrected planet. When there is no *śīghra* equation, the true planet is the *manda*-corrected planet, and the difference between the true and the mean planets is the *manda* equation.

~ THE ŚĪGHRA APOGEE OF THE SUPERIOR PLANETS ~

(43) When Saturn, Mars, or Jupiter are located in front of the sun, the longitude of the true planet is seen to be less than [the longitude of] the mean planet, [whereas] when they are located behind [the sun], it is seen as greater. Therefore it is pointed out by the ancients that [the longitude of] the *śīghra* apogee of [these] three [planets] is equal to [the longitude of] the [mean] sun.

In the case of the superior planets, i.e., Mars, Jupiter, and Saturn, the longitude of the *śīghra* apogee is always that of the mean Sun.¹⁷

~ TO FIND THE LONGITUDE OF A PLANET ~

(44^{a-b}) Knowing that when there is no *manda* equation, [the longitude of] a planet is equal to [the longitude of its] *manda* perigee or apogee, its

¹⁷See [71 . 557].

measure is to be computed.

It is not quite clear how the longitude of the planet is to be computed from the knowledge that it is equal to the longitude of the *manda* perigee or apogee when there is no *manda* equation.

~ TO FIND THE VELOCITIES OF MERCURY AND VENUS ~

(44^{c-d}) [The true longitudes of] Venus or Mercury are to be determined [when the planets are] on the horizon, [so that their longitudes are] equal to [the longitude of] the ascendant. Their velocities are to be computed from those [longitudes].

When Mercury or Venus are on the horizon, their longitudes can be taken to be equal to that of the ascendant (as the two planets are on their own inclined orbits, their positions will generally not coincide with that of the ascendant, but we can assume that they approximately are). Repeating this observation, we can find their velocities.

~ TO FIND THE REVOLUTIONS OF MERCURY AND VENUS IN A KALPA ~

(45) For as long a time as [Mercury and Venus] are located in front of the sun, so long are they always located behind [it]. Therefore, for the sake of computing [the longitudes of] Mercury and Venus it is to be known that [their] revolutions during a *kalpa* are equal to the revolutions of the sun [in the same period of time].

Since Mercury and Venus are seen as much in front of the Sun as behind it, it can be inferred that their mean motion is identical to that of the Sun. Hence they have the same number of revolutions in a *kalpa* as the Sun.

~ FINDING THE REVOLUTIONS OF VENUS AND MERCURY ~

(46–49) The number of *ghaṭikās* elapsed since the rising of Venus is produced by means of its own shadow and by means of computation. Since that is what has elapsed of the day [of Venus] for a person at the center of the Earth, so one's own [time] is easily computed by a water clock. [Verse unclear, translation needs revision.]

If the *yojanas* measured by the radius of the earth [are attained] by means of the difference between the two elapsed [parts] of the day, then

what [is attained] from the measure of *ghaṭikās* in a nychthemeron? The result in this case is [the *yojanas* in] the orbit by means of a proportion.

Half of the sum of the maximum and minimum [values of] that [orbit] is the mean orbit of the *śīghra* apogee of Venus. The orbit of the sky divided by that is the number of revolutions of the *śīghra* apogee of Venus [in a *kalpa*].

In this very way one should [also] compute the revolutions of the *śīghra* [apogee] of Mercury. Thus is the excellent method taught. The revolutions of the *manda* [apogees], the *śīghra* [apogees], the [mean] planets, and the nodes are correct as per the words of the ancient sages.

The phrasing of verse 46 is not clear. However, given the contents of verse 47, the meaning has to be the following. The time that Venus rises on the local horizon is not the same as the computed time, which is found with respect to the center of the Earth. We have to find the time between the computed time and the time since rising on the local horizon.

The difference of these two times corresponds to Venus moving a distance roughly equal to the radius of the Earth. This is completely analogous to the procedure described in 1.1.69–75. It is clear that the average between the greatest orbit and the smallest orbit yields the mean orbit. In addition, since we are dividing the orbit of the sky with the number found, we get the *śīghra* motion of the inferior planet in question.¹⁸

~ TO COMPUTE THE DAY COUNT ~

(50–51) The number of years elapsed since the commencement of [planetary] motion is multiplied by 12 and increased by the elapsed months [of the current year]. [The result] is multiplied by 30 and increased by the [elapsed] *tithis* [of the current month]. [This result is written down] separately [in two places]. [The first place] is multiplied by the given [number of] intercalary months [in a *mahāyuga*]. [The second place] is increased by the elapsed intercalary months multiplied by 30, [the elapsed intercalary months being found as] the result of the division of [the first result] by the *saura* days [in a *mahāyuga*]. [This result is written down] separately [in two places]. [The first place] is multiplied by the omitted *tithis* in a [mahā]yuga. [The second place] is diminished by the elapsed omitted *tithis* [found as] the result of the division of [the first result] by the [number of] *tithis* [in a *mahāyuga*].

¹⁸See [71 . 556].

This formula for computing the elapsed civil days between the commencement of planetary motion and the present is common and found in all *siddhāntas*.

Let y be the number of elapsed *saura* years between the commencement of planetary motion and the present, let n be the number of elapsed *saura* months between the commencement of planetary motion and the present, let m be the number of elapsed lunar months in the current year, let t' be the number of elapsed *tithis* in the current month, let s be the number of elapsed *saura* days between the commencement of planetary motion and the present, let a be the number of elapsed intercalary months between the commencement of planetary motion and the present, let t be the number of elapsed *tithis* between the commencement of planetary motion and the present, let u be the number of elapsed omitted *tithis* between the commencement of planetary motion and the present, and let c be the number of elapsed civil days between the commencement of planetary motion and the present. We want to compute c .

The computation proceeds as follows:

$$12 \times y = n \quad (3.15)$$

$$30 \times (n + m) + t' = s \quad (3.16)$$

$$s \times \frac{A}{S} = a \quad (3.17)$$

$$s + 30 \times a = t \quad (3.18)$$

$$t \times \frac{U}{T} = u \quad (3.19)$$

$$t - u = c \quad (3.20)$$

Notice that in (3.16) we treat the elapsed lunar months as *saura* months and the elapsed *tithis* of the current month as *saura* days, which is incorrect, but always done in Indian astronomical texts. The computations in (3.18) and (3.20) follow from 2.1.12–17.

~ TO FIND THE WEEKDAY FROM THE DAY COUNT ~

(52) **The day count, which arises from the measure of the mean days of the sun, begins with a Sunday.**

One should subtract the part when it is larger from the residue of the omitted *tithis* and the intercalary months [?].

A civil day is called a day of the Sun because it is the time between two consecutive sunrises. The first day after the planets begin their motion is a Sunday.

The last half of the verse is not clear.

~ TO COMPUTE THE DAY COUNT ~

(53) **[When] the number of lapsed *saura* years [since the beginning of**

planetary motion] are multiplied by 12 and [then] increased by the [lapsed] months [of the current year] starting with *caitra*, [the result is the lapsed *saura* months since the beginning of planetary motion]. [When the number of lapsed *saura* months is] multiplied by 30 and [then] increased by the [lapsed] *tithis* [of the current month], the [lapsed] *saura* days [since the beginning of planetary motion] are [the result]. Having computed the [lapsed] *adhimāsas* [since the beginning of planetary motion] by means of those [lapsed *saura* days] put down in two places, [the lapsed *saura* days] are increased by those [lapsed *adhimāsas*] converted into *tithis*. [The result] is the [number of lapsed] *tithis* [since the beginning of planetary motion], which is put down in two places. [The number of lapsed *tithis*] diminished by the omitted *tithis* [since the beginning of planetary motion], which are found by means of a proportion, is [the number of lapsed] civil [days since the beginning of planetary motion].

This is the same formula for computing the day count as was given in verses 50–51.

~ TWO ALTERNATIVE DAY COUNTS ~

(54–55) The beginning of the *saura* year [occurs] at [the Sun’s] entry into Aries. The epact is the difference between that [point in time] and the beginning of the month of *caitra*. By means of that [epact] subtracted from the beginning of the *saura* year, [we get,] in a different way, a day count commencing from the beginning of the bright [*pakṣa*] of *caitra*.

The residue of the omitted *tithis* is always found as the difference between midnight and the end of the *tithi*. By means of that [residue] subtracted from the time of [mid]night, [we get] a day count [commencing at the end of a given *tithi*], and the computation of [the mean longitudes of] the planets [can be accomplished] from that.

The month in which the Sun enters the sign Aries is called *caitra*. The Sun’s entry into Aries marks the beginning of the *saura* year, and *caitra* is the first month of the year. In general, the beginning of *caitra* does not coincide with the Sun’s entry into the sign Aries. The time between the two is called the epact (*śuddhi*). When the epact is subtracted from the beginning of the *saura* year, i.e., from the time of the Sun’s entry into Aries, we get the time of the beginning of *caitra*. This point in time can be used as the starting point for a day count instead of the commencement of planetary motion.

The remainder of the accumulated omitted *tithis* is the difference between midnight and the end

of the *tithi*. We can find the end of a given *tithi* from the time of midnight and knowledge of this remainder, and we can use this point in time for a day count. However, why one would want to use the end of a *tithi* for this purpose is unclear.

~ TO FIND THE MEAN PLANET FROM THE DAY COUNT ~

(56) The result from [the division of] the given day count multiplied by the revolutions [of a given planet in a *mahāyuga*] by the civil days [in a *mahāyuga*] is the rotations and so on [of the planet during the day count].

[The longitude of] the planet [found from a given day count] is [for] when it is midnight at [Laṅkā,] the city of the ten-headed [Rāvaṇa,] as determined by the mean Sun.

Let r be the number of revolutions of the given planet in a *mahāyuga*. If d is the day count starting from the commencement of planetary motion, then it is clear that

$$360 \times r \times \frac{d}{C} \quad (3.21)$$

is the number of degrees traveled by the planet during the day count d . Subtracting the largest possible multiple of 360 from this, we get the planet's longitude.

The *saurapakṣa* employs a midnight system rather than a sunrise system. Thus the longitude determined is the planet's longitude at midnight in Laṅkā on the day given by the day count.

~ TO FIND THE DHRUVA OF A PLANET ~

(57) The number of [elapsed] years in the *śaka* [era] of Śālivāhana is diminished by 1425. [The result] multiplied by the multiplier of a [given] planet and increased by the addend [of the planet] is the *dhruva* for the [present] year.

The multipliers and the addends are given in the following verses by Jñānarāja, and are discussed in the notes on these verses. Put simply, the multiplier of a planet is the distance it travels during a *saura* year, and the addend of a planet is its position at a particular time in the year *śaka* 1425. The point in time corresponding to the addends of the planets is called the epoch.

Let g and a be the multiplier and the addend of a given planet. If n years have elapsed since *śaka* 1425, we compute $(n - 1425) \times g + a$. The result gives us the position of the planet exactly n *saura* years after the epoch. This position is called the planet's *dhruva* for that year.

As we shall see in the notes to the next verses, the epochal date corresponds to sunrise on a particular day. However, the positions found for an integral number of *saura* years after the epochal

date do not correspond in a simple manner to sunrise (or any other given time of a nychthemeron), and are thus of limited use.

~ MULTIPLIERS AND ADDENDS ~

(58–64) In the case of the moon, the multiplier in rotations and so on is 4 [signs], 12 [degrees], 46 [minutes], 40 [seconds, and] 48 [thirds]. In the case of Mars, [it is] 6 [signs], 11 [degrees], 24 [minutes], 9 [seconds, and] 6² [i.e., 36 thirds]. In the case of [the *śīghra* of] Mercury, [it is] 1 [sign], 24 [degrees], 45 [minutes], 18 [seconds, and] 0 thirds]. The multiplier of Jupiter is 1 [sign], 0 [degrees], 21 [minutes], 6 [seconds, and] 0 thirds]. The multiplier of [the *śīghra* of] Venus is 7 [signs], 15 [degrees], 11 [minutes], 52 [seconds, and] 48 [thirds]. For Saturn, [it is] 0 [signs], 12 [degrees], 12 [minutes], 50 [seconds, and] 24 [thirds]. In the case of the lunar apogee, [it is] 1 [sign], 10 [degrees], 41 [minutes], 0 [seconds, and] 54 [thirds]. For the lunar node, [it is] 0 [signs], 19 [degrees], 21 [minutes], 11 [seconds, and] 24 [thirds]. In the case of the Lord of the Year, this [multiplier] in [civil] days and so on is 1;15,31,31,24. In the case of the lunar epact, the multiplier in *tithis* and so on is 11;3,53,24.

The multipliers are [to be computed as] the revolutions [of the planets in a *kalpa*] divided by the years in a *kalpa*.

The addends [are as follows]. [The addend] of the sun is 6 [signs], 0 [degrees], 14 [minutes, and] 47 [seconds]. In the case of the moon, [it is] 9 [signs], 9 [degrees], 35 [minutes, and] 42 [seconds]. In the case of Mars, [it is] 1 [signs], 3 [degrees], 34 [minutes, and] 43 [seconds]. In the case of the *śīghra* of Mercury, [it is] 4 [signs], 0 [degrees], 24 [minutes, and] 14 [seconds]. In the case of Jupiter, [it is] 2 [signs], 14 [degrees], 16 [minutes, and] 12 seconds. In the case of the *śīghra* of Venus, 10 [signs], 4 [degrees], 35 [minutes, and] 30 [seconds]. In the case of Saturn, [it is] 2 [signs], 19 [degrees], 22 [minutes, and] 17 [seconds]. In the case of the [lunar] apogee, [it is] 7 [signs], 7 [degrees], 35 [minutes, and] 14 [seconds]. In the case of the [lunar] node, [it is] 0 [signs], 11 [degrees], 39 [minutes, and] 53 [seconds]. In the case of the Lord of the Year, [it is] 4;18,53,0 in [civil] days and so on. In the case of the epact, [it is] 2;29,34,0 in *tithis* and so on.

In these verses, Jñānarāja gives the multipliers and addends for the planets, the lunar apogee,

Planet	Multiplier	Addends	
the sun	—	6 ^s 0°14'47"	
the moon	4 ^s 12°46'40''48'''	9 ^s 9°35'42"	
Mars	6 ^s 11°24'9''36'''	1 ^s 3°34'43"	1 ^s 3°42'35"
Mercury (<i>śighra</i>)	1 ^s 24°45'18''0'''	4 ^s 0°24'14"	4 ^s 0°25'20"
Jupiter	1 ^s 0°21'6''0'''	2 ^s 14°16'12"	
Venus (<i>śighra</i>)	7 ^s 15°11'52''48'''	10 ^s 4°35'30"	10 ^s 4°35'29"
Saturn	0 ^s 12°12'50''24'''	2 ^s 19°22'17"	
Lunar apogee	1 ^s 10°41'0''54'''	7 ^s 7°35'14"	
Lunar node	0 ^s 19°21'11''24'''	0 ^s 11°39'53"	0 ^s 11°40'9"
Lord of the Year	1;15,31,31,24	4;18,53,0	4;18,53,25,36
Epact	11;3,53,24,0	2;29,34,0	2;29,33,36

Table 3.3: Multipliers and addends

the lunar node, the Lord of the Year, and the epact. The epact was defined earlier (verses 54–55). The multiplier for the epact is the epact accumulated during a *saura* year, while the addend for the epact is the accumulated epact at the beginning of *śaka* 1425. The Lord of the Year for a given year is the time in days between the Sun’s entry into Aries (which marks the beginning of the year) and the end of the preceding week. As such, it determines the weekday that begins the current year, and it is called “Lord of the Year” because the deity associated with this weekday is said to rule that year. The addend for the Lord of the Year is the Lord of the Year for *śaka* 1425, and its multiplier is the excess of an integral number of weeks accumulated during a *saura* year. Note that for the epact and the Lord of the Year, the addends correspond to the beginning of *śaka* 1425 rather than to the epoch later in that year. Why this is so is clear from the definitions of the two.

The multipliers and the addends are listed in table 3.3. The entries in the third row give my computation of the addends; if an entry is blank, it is because there is no difference with the value given by Jñānarāja.

The multiplier of a planet is the angular distance traveled by the mean planet during a *saura* year. If R_p is the number of revolutions of the planet in a *mahāyuga*, it moves a total of $360 \times R_p$ degrees during a *mahāyuga*.¹⁹ Therefore, the number of degrees that the planet moves during a *saura* year is $\frac{360 \times R_p}{Y}$. Depending on the planet, this number might exceed 360 degrees. If so, we diminish the result by the largest multiple of 360 contained in it, which leaves us with a number g satisfying $0 \leq g < 360$. For example, if the planet travels $1^{\text{rot}} 2^s 29^\circ 1' 23'' 12'''$ in a *saura* year, we get $g = 2^s 29^\circ 1' 23'' 12'''$ (1^{rot} is one rotation, i.e., 360° , and 1^s is a sign, i.e., 30°). This number g is the planet’s multiplier. It gives the degrees in excess of a whole number of rotations that the planet moves during a *saura* year.

Since $\frac{360 \times 60^3}{Y} = 18$, any given multiplier for a planet (or for the Moon’s apogee and node) will

¹⁹While Jñānarāja says that the multiplier of a planet is to be found as the revolutions of the planet in a *kalpa* divided by the *saura* years in a *kalpa*, the revolutions and *saura* years in a *mahāyuga* will do just as well. Also, more precisely, the ratio has to be multiplied by 360, as we want the multiplier expressed in degrees, not in rotations.

have at most three sexagesimal places. In fact, all the planetary multipliers as given by Jñānarāja are exact. Similarly, the values of the Lord of the Year and the epact are both exact.

Now, the addends are mean planetary positions (as well as the accumulated Lord of Year and epact) corresponding to a given point in time, the epoch, as explained in the commentary to verse 57. We know that the epoch falls in the year *śaka* 1425. The addend of the Sun, which is the mean longitude of the Sun at the epoch, will help us to determine it precisely. Since the addend of the Sun is $6^s0^o14'47''$, the mean Sun is $0^o14'47''$ into the sign Libra at the time of the epoch, or, equivalently, $\frac{6;0,14,47}{12}$ of a *saurya* year (based on mean motion) has elapsed between the beginning of the year *śaka* 1425 and the epoch. This is slightly more than half a *saurya* year.

From verses 4–5, we know that 1,955,883,179 *saurya* years elapsed between the commencement of planetary motion and the commencement of the *śaka* era. Therefore,

$$1,955,883,179 + 1425 = 1,955,884,604 \quad (3.22)$$

saurya years elapsed between the commencement of planetary motion and the beginning of the year *śaka* 1425. If $R_{\mathcal{L}}$ denote the revolutions of the Moon in a *mahāyuga*, the longitude of the mean Moon is therefore

$$1,955,884,604 \times \frac{R_{\mathcal{L}}}{Y} = 29^o54'43''12''' \quad (3.23)$$

at the beginning of *śaka* 1425 (the Sun's mean longitude at the beginning of *śaka* 1425 is, of course, $0^s0^o0'0''0'''$). Furthermore, since the mean Moon moves

$$\frac{1}{2} \times \frac{360 \times R_{\mathcal{L}}}{Y} = 6^{\text{rot}}8^s6^o23'20''24''' \quad (3.24)$$

during half of a *saurya* year, it is easy to see that the mean Moon will overtake the mean Sun 6 times between the beginning of *śaka* 1425 and the epoch. In Jñānarāja's system, a month begins at a conjunction of the Sun and the Moon, and the beginning of a *saurya* year takes place in the month of *caitra*. Hence the month current at the time of the epoch is *āśvina*. Furthermore, noting that the difference between the mean longitudes of the Moon and the Sun at the time of the epoch are

$$9^s9^o35'42'' - 6^s0^o14'47'' = 3^s9^o20'55'' = (8 \times 12 + 3)^o20'55'', \quad (3.25)$$

and

$$\frac{3^o20'55''}{12} = 0;16,44,35, \quad (3.26)$$

we see that about 8;16,45 *tithis* have elapsed of the month of *āśvina* at the time of the epoch.

A computation of mean longitudes based on the *Sūryasiddhānta* shows that the epoch corresponds to local sunrise in Jñānarāja's area on Friday, September 29, 1503 CE.²⁰

Since 1,955,884,604 years have elapsed between the beginning of planetary motion and the beginning of the year *śaka* 1425, the accumulated Lord of the Year for that time can be found as

$$1,955,884,604 \times 1;15,31,31,24 = \frac{664735254025007}{270000} \equiv_7 4;18,53,25,36 \quad (3.27)$$

²⁰I am grateful to Michio Yano for running this computation for me.

and the accumulated epact as

$$1,955,884,604 \times 11;3,53,24,0 = \frac{32462305743739}{1500} \equiv_{30} 2;29,33,36. \quad (3.28)$$

~ A DAY COUNT FOR THE EPOCHAL DATE ~

(65) The day count [for the beginning of the year] is the *tithis* elapsed since the beginning of *caitra* diminished [first] by *tithis* of the epact and [then] by the *ghaṭikās* of the Lord of the Year. The weekday is [counted] from the Lord of the Year. The day count is to be imagined as follows the difference between half a *saura* year and the day count for the sake of the computation of [the mean longitudes of] the planets.

The day count is here defined as the elapsed *tithis* since the beginning of the month of *caitra* diminished by two quantities: the accumulated epact and the *ghaṭikās*, i.e., the fractional part, of the Lord of the Year. By subtracting the accumulated epact from the elapsed *tithis*, we arrive at the time of the Sun's entry into Aries, which is the beginning of the year. However, the Sun does not necessarily enter Aries right at the beginning of a weekday. By the definition of the Lord of the Year, if we subtract the *ghaṭikās* of the Lord of the Year from the previous result, we get the point in time of the beginning of the weekday during which the Sun's entry into Aries occurred. In the case of the year *śaka* 1425, the Sun's entry into Aries occurred 4;18,53 civil days after the beginning of the previous Sunday. Subtracting the *ghaṭikās* of the Lord of the Year, i.e., 18;53 *ghaṭikās*, from the time of the Sun's entry into Aries, we get the beginning of the weekday during which the Sun entered Aries in *śaka* 1425.

Although it is not made clear, it appears that what Jñānarāja intends to do with this verse is to establish a day count starting from the epochal date. Assuming that more than half of *śaka* 1425 has passed, if the day count established for the beginning of the year is subtracted from half a year, we get a new day count starting from the epochal date. This is peculiar, though, as the epochal date corresponds to local sunrise, whereas the *saurapakṣa* operates with a midnight system.

Note that what is translated merely as “epact” in the verse is really given as *vigatartuśuddhi*. The word *vigatartu* is literally “elapsed season,” but it is not clear how exactly it is to be interpreted here.

~ MEAN LONGITUDE OF THE SUN FROM THE DAY COUNT ~

(66) The degrees of [the mean longitude of] the Sun [are found as follows]. The day count is diminished by its own sixtieth part, [and then the result is] increased in its first sexagesimal place by its own seventh part and decreased in its second sexagesimal place by one-fourth of the day count.

The result is a negative and positive contribution to the planets depending on the hemisphere that the sun [is in].

This and the following seven verses give formulae for computing the mean longitudes of the planets from the day count. Note that in order for the formulas to work properly, the day count in question has to start from the commencement of planetary motion (or at least from a point in time where the mean planets are all at Aries 0°).

The last part of the verse (its fourth *pāda*) seems out of place here. What is translated in that part as “result”, is the Sanskrit word *phala*, which could also be taken as “equation of center”. At any rate, this passage does not make any sense where it is found.

Now, if the day count is a , then the angular distance in degrees traveled by a planet during the day count s is

$$s = a \times \frac{360 \times R_p}{C}, \quad (3.29)$$

where R_p is the number of revolutions of the planet in a *mahāyuga*. Clearly, $\bar{\lambda}_p \equiv_{360} s$, where $\bar{\lambda}_p$ is the longitude of the mean planet.

Let $\bar{\lambda}_\odot$ be the mean longitude of the Sun and $R_\odot$ be the revolutions of the Sun in a *mahāyuga*. Then according to the verse we have

$$\bar{\lambda}_\odot \equiv_{360} a \times \left(1 - \frac{1}{60} + \left(1 - \frac{1}{60} \right) \times \frac{1}{7 \times 60} - \frac{1}{4 \times 60^2} \right) = a \times \frac{99349}{100800}. \quad (3.30)$$

From this, the mean velocity of the Sun during one civil day comes out to be $\frac{99349}{100800} = 0;59,8,10,42,51^\circ$. Since

$$\frac{99349}{100800} - \frac{360 \times R_\odot}{C} = \frac{99573493}{39763529265600} < 0;0,0,0,33, \quad (3.31)$$

we see that this is a good approximation.

~ MEAN LONGITUDE OF THE MOON FROM THE DAY COUNT ~

(67) The day count is multiplied by 13 and put down in two places. [One place is] multiplied by 10 and divided by 737, [and then] added to the result [in the other place]. [The result of] that with its second sexagesimal place diminished by the eighth part of the day count is [the mean longitude of] the Moon in degrees and so on.

When Jñānarāja says that a quantity, say x , is to be subtracted from the second sexagesimal place of another quantity, say y , what is intended is $y - \frac{x}{60^2}$.

Let $\bar{\lambda}_\text{☾}$ be the mean longitude of the Moon and $R_\text{☾}$ be the number of revolutions of the Moon in a *mahāyuga*. The formula given for the mean longitude of the moon is

$$\bar{\lambda}_\text{☾} \equiv_{360} a \times \left(13 + 13 \times \frac{10}{737} - \frac{1}{8 \times 60^2} \right) = a \times \frac{279676063}{21225600}. \quad (3.32)$$

This gives a mean velocity of the Moon during one civil day as 13;10,34,52,54,25,24°.

Since

$$\left(13 + 13 \times \frac{10}{737} - \frac{1}{8 \times 60^2}\right) - \frac{360 \times R_{\mathcal{L}}}{C} = \frac{32693993791}{8373063162499200} < 0;0,0,0,51, \quad (3.33)$$

this is a good approximation.

~ MEAN LONGITUDE OF MARS FROM THE DAY COUNT ~

(68) **Half of the day count [is] increased by its own twenty-first part. [Then] the day count diminished by a quarter [of itself] is added to the second sexagesimal place [of the result]. [This is] the [mean longitude of] Mars in degrees and so on.**

Let $\bar{\lambda}_{\mathcal{O}}$ be the mean longitude of Mars and $R_{\mathcal{O}}$ be the number of revolutions of Mars in a *mahāyuga*. The formula given is

$$\bar{\lambda}_{\mathcal{O}} \equiv_{360} a \times \left(\frac{1}{2} + \frac{1}{2 \times 21} + \frac{3}{4 \times 60^2}\right) = \frac{5869}{11200}. \quad (3.34)$$

Since

$$\frac{360 \times R_{\mathcal{O}}}{C} - \left(\frac{1}{2} + \frac{1}{2 \times 21} + \frac{3}{4 \times 60^2}\right) = \frac{6722867}{4418169918400} < 0;0,0,0,20, \quad (3.35)$$

this is again a good approximation.

~ MEAN LONGITUDE OF MERCURY'S ŚĪGHRA APOGEE FROM THE DAY COUNT ~

(69) **[To compute] the degrees of [the mean longitude of] the śīghra apogee of Mercury, the day count is multiplied by 4, [the result is first] increased in its first sexagesimal place by what is obtained [as the quotient of the division of] 9 into the day count multiplied by 50, [and then] diminished by the [day] count in the second sexagesimal place.**

Let $\bar{\lambda}_{\mathcal{P}}$ be the mean longitude of the śīghra apogee of Mercury and $R_{\mathcal{P}}$ be the number of revolutions of the śīghra apogee of Mercury in a *mahāyuga*. The verse gives the formula

$$\bar{\lambda}_{\mathcal{P}} \equiv_{360} a \times \left(4 + \frac{50}{9 \times 60} - \frac{1}{60^2}\right) = a \times \frac{44197}{10800}. \quad (3.36)$$

Since

$$\frac{360 \times R_{\mathcal{P}}}{C} - \left(4 + \frac{50}{9 \times 60} - \frac{1}{60^2}\right) < 0;0,0,0,41, \quad (3.37)$$

this is a good approximation.

~ MEAN LONGITUDE OF JUPITER FROM THE DAY COUNT ~

(70) In the case of [the mean longitude of] Jupiter, [the procedure is as follows]. [First] the day count is multiplied by 3 and divided by 20, and [the result] is subtracted from the day count. [This quantity is applied] negatively [to] the second sexagesimal place [of] the minutes of arc and so on that are given by the day count multiplied by 5.

Let $\bar{\lambda}_{\text{J}}$ be the mean longitude of Jupiter and R_{J} be the revolutions of Jupiter in a *mahāyuga*. The formula given for the mean longitude of Jupiter is

$$\bar{\lambda}_{\text{J}} \equiv_{360} a \times \left(\frac{5}{60} - \frac{1 - \frac{3}{20}}{60^2} \right) = a \times \frac{5983}{72000}. \quad (3.38)$$

Since

$$\left(\frac{5}{60} - \frac{1 - \frac{3}{20}}{60^2} \right) - \frac{360 \times R_{\text{J}}}{C} = \frac{24991231}{28402520904000} < 0;0,0,0,12, \quad (3.39)$$

we again have a good approximation.

~ MEAN LONGITUDE OF VENUS' ŚĪGHRA FROM THE DAY COUNT ~

(71^{ab}) In the case of [the mean longitude of] the *śīghra* [apogee] of Venus, the result for the sun by increased by its own half is [further] increased by the eighth part of the [day] count diminished by [its own] one-hundredth part.

Let $\bar{\lambda}_{\text{V}}$ be the mean longitude of the *śīghra* apogee of Venus and R_{V} be the number of revolutions of the *śīghra* apogee of Venus in a *mahāyuga*. The formula for the mean longitude of the *śīghra* apogee of Venus is

$$\begin{aligned} \bar{\lambda}_{\text{V}} &\equiv_{360} a \times \left(1 - \frac{1}{60} + \left(1 - \frac{1}{60} \right) \times \frac{1}{7 \times 60} - \frac{1}{4 \times 60^2} \right) \times \frac{3}{2} + a \times \left(\frac{1}{8} - \frac{1}{8 \times 100} \right) \\ &= \frac{21533}{13440} \end{aligned} \quad (3.40)$$

Since

$$\frac{21533}{13440} - \frac{360 \times R_{\text{V}}}{C} = \frac{60137981}{5301803902080} < 0;0,0,3, \quad (3.41)$$

this is a good approximation.

~ MEAN LONGITUDE OF SATURN FROM THE DAY COUNT ~

(71^{cd}) [The mean longitude of] Saturn in degrees and so on is the day count divided by 30 with its first sexagesimal place increased by the one-hundredth and sixtieth part of the [day] count.

Let $\bar{\lambda}_{\text{h}}$ be the mean longitude of Saturn and R_{h} be the number of revolutions of Saturn in a *mahāyuga*. For the mean longitude of Saturn, we are given the formula

$$\bar{\lambda}_{\text{h}} \equiv_{360} a \times \left(\frac{1}{30} + \frac{1}{60 \times 160} \right) = \frac{107}{3200}. \quad (3.42)$$

Since

$$\frac{360 \times R_{\text{h}}}{C} - \left(\frac{1}{30} + \frac{1}{60 \times 160} \right) = \frac{2282101}{1262334262400} < 0;0,0,0,24, \quad (3.43)$$

this is a good approximation.

~ LONGITUDE OF THE LUNAR APOGEE FROM THE DAY COUNT ~

(72^{a-c}) [The longitude of] the lunar apogee in degrees and so on [can be computed as follows]. The day count divided by 10. In the first sexagesimal place [the result] is increased by the day count diminished by its own third part and increased by the forty-first part [of the day count diminished by its own third part].

Let λ_A be the longitude of the lunar apogee and R_A be the number of revolutions of the lunar apogee. The longitude of the lunar apogee can be found from the formula

$$\lambda_A \equiv_{360} a \times \left(\frac{1}{10} + \frac{1}{60} \times \left(\left(1 - \frac{1}{3} \right) + \frac{1}{41} \times \left(1 - \frac{1}{3} \right) \right) \right) = a \times \frac{137}{1230}. \quad (3.44)$$

Since

$$\frac{360 \times R_A}{C} - \frac{137}{1230} = \frac{386491}{485209732110} < 0;0,0,0,11, \quad (3.45)$$

it is a good approximation.

~ LONGITUDE OF THE LUNAR NODE FROM THE DAY COUNT ~

(72^{d-73}) [Now,] according to the regular order, I will explain the [formula for] the lunar node. The day count [is first] multiplied by 10 and divided by 3, [and then that quantity is] diminished by its own twenty-second part. [The result is the mean longitude of] the lunar node in minutes of arc and so on.

[The mean longitudes of] the planets are [equal to] their own *dhruvas* at [sun]rise.

Let λ_{O} be the longitude of the lunar node and R_{O} be the number of revolutions of the lunar node in a *mahāyuga*. The longitude of the lunar node can be found from the formula

$$\lambda_{\text{O}} \equiv_{360} a \times \left(\frac{10}{3} - \frac{1}{22} \times \frac{10}{3} \right) \times \frac{1}{60} = a \times \frac{7}{132}. \quad (3.46)$$

Since

$$\left(\frac{10}{3} - \frac{1}{22} \times \frac{10}{3}\right) \times \frac{1}{60} - \frac{360 \times R_{\delta\Omega}}{C} = \frac{2368759}{52071288324} < 0;0,0,10, \quad (3.47)$$

it is a good approximation.

The last part of the verse is not clear.

~ TO FIND THE MEAN LONGITUDE OF A PLANET ~

(74) The [mean] velocity of a planet [which has a mean longitude] that is not known is multiplied by the known [mean longitude of another] planet and divided by the [mean] velocity of the planet [who has a mean longitude] that is known. The result is the [mean longitude of the] planet [who has a mean longitude] that was not known [previously].

The above attempt at a literal translation of the verse does not read well, but the idea is as follows. Given two planets, say P_1 and P_2 , let their mean longitudes and mean velocities be $\bar{\lambda}_1$ and $\bar{v}_1$, and $\bar{\lambda}_2$ and $\bar{v}_2$, respectively. Assuming that $\bar{\lambda}_1$, $\bar{v}_1$, and $\bar{v}_2$ are known, the verse states that $\bar{\lambda}_2$ can be found as

$$\bar{\lambda}_2 = \frac{\bar{v}_2 \times \bar{\lambda}_1}{\bar{v}_1}. \quad (3.48)$$

As can be easily seen, this formula does not work. For example, in verses 58–64, we had a situation where the mean longitude of the Sun is $\bar{\lambda}_{\odot} = 180^{\circ}14'47''$ and the mean longitude of the Moon is $\bar{\lambda}_{\zeta} = 279^{\circ}35'42''$. Assuming that the Sun is the planet whose mean longitude is known, the formula gives us, incorrectly, that

$$\bar{\lambda}_{\zeta} = \frac{\bar{v}_{\zeta} \times \bar{\lambda}_{\odot}}{\bar{v}_{\odot}} = \frac{13;10,34 \times 180;14,47}{0;59,8} = \frac{15389652979}{6386400} \equiv_{360} 249;45,14. \quad (3.49)$$

The reason for the failure of the formula in the above example is that we have not taken into account that each planet has moved a certain number of whole rotations since the commencement of planetary motion. If we instead of longitudes between 0° and 360° use the total angular distance traveled by the planet since the commencement of planetary motion, the formula works.

~ INSERTION OF AN INTERCALARY MONTH ~

(75) If an unattained intercalary month is attained, then the epact is diminished by 30 [and] the day count is to be computed from that at the middle of the year. Then the [number of] elapsed intercalary months is diminished by 1.

The idea is as follows. Gradually, over time, a residue of an intercalary month accumulates. When this residue reaches 1, it contains a full intercalary month, which is then inserted. It is not clear why the number of intercalary months should be diminished by 1, though.

~ DEFINITION OF REGULAR, OMITTED, AND INTERCALARY MONTHS ~

(76) **A normal lunar month [occurs] when it contains a *saṅkrānti*. When this is not the case, an omitted [month] or an intercalary [month] is produced.**

A *saṅkrānti* is the passage of the Sun from one zodiacal sign to the next. If such a passage occurs during a lunar month, that month is said to be a regular month, or a normal month. The majority of months fall in this category. If no *saṅkrānti* occurs during a month, that month is called an intercalary month. If two *saṅkrāntis* occur during a month, that month is called an omitted month.

~ ORDER OF THE MONTHS ~

(77) **The lunar month during which the entry of the sun into Aries takes place is called *madhu*. [The months] *mādhava* and so on occur with [the entry of the sun into] Taurus and so on.**

The first month of the year, *caitra* or *madhu*, is the lunar month during which the Sun enters the sign Aries. Similarly, during the second month the Sun enters Taurus, and so on. The names of the months are, in order: *madhu*, *mādhava*, *śukra*, *śuci*, *nabha*, *nabhasya*, *iṣa*, *ūrja*, *saha*, *sahasya*, *tapa*, and *tapasya*. In addition to these descriptive names, the months are also named after the *nakṣatra*, or constellation in the path of the Moon, at which the full moon in that month occur. In this system, the names of the months are: *caitra*, *vaiśākhā*, *jyaiṣṭhā*, *āṣāḍhā*, *śrāvaṇa*, *bhādrapada*, *āśvina*, *kārttika*, *mārgaśīrṣa*, *pauṣya*, *māgha*, and *phālguna*.

~ THE DURATION OF A SAURA YEAR ~

(78) **Since a *saura* year is [measured] by 12 lunar months, 11 *tithis*, 3 *ghaṭikās*, and 53 *palas*, whatever is greater than the increase of the year, that is an intercalary month [measured] by 32;16. 30 *tithis* is a mean [intercalary month].**

The first part is clear, for

$$\frac{T}{Y} - 12 \times 30 = \frac{66389}{6000} = 11;3,53,24. \quad (3.50)$$

We thus have the duration of a *saura* year measured in *tithis*. However, the second part of the verse is not clear (but compare the next verse).

~ CONCERNING TYPES OF MONTHS ~

(79) If one civil day [comes about] by means of the mean motion of the Sun, then what [arises] in a sign? A *saura* month, and the lunar month is [found] in the difference of the velocities. If there is one civil day of the Sun, then what is in a revolution? A *saura* [month] is greater than a lunar month, and an intercalary month is [measured] by 32; 16.

The verse is not clear (but compare the previous verse).

~ DEFINITION OF A MONTH ~

(80) A month [begins] from a conjunction [of the Sun and the Moon] and ends at the [next] conjunction. If there is an entry of the Sun into a sign during that [time], [the month] is a regular one, otherwise it is an intercalary one.

The significance of the word *maṇḍalanāḍīkāntam* in *pāda* a is not clear to me and is not included in the translation. Otherwise, the verse is clear. A month is the duration from one conjunction of the Sun and the Moon to the next. Normally the Sun will enter a sign in that time, in which case the month is a regular month. However, if this is not the case, the month is either omitted or intercalary, see verse 76. Here only the intercalary option is given.

~ SURFACE OF THE EARTH AS REFERENCE POINT FOR CONJUNCTIONS ~

(81–82) Whatever has been stated [in the preceding] with respect to those at the center of the Earth I will now explain with respect to those on the surface of the Earth.

The computed time of conjunction [of the Sun and the Moon] is corrected [when] rectified by the longitudinal parallax.

Since at the corrected time of conjunction [of the Sun and the Moon], the Sun and the Moon are certainly situated on the [same] line of vision, those who know the sphere say that.

Note that we have to imagine that there is an “observer” or “observers” at the Earth’s center. If such an observer is postulated, he will see the conjunction of the Sun and the Moon at a different time than an observer on the surface of the Earth. This is due to parallax, a topic that is dealt with exhaustively in the section on solar eclipses beginning on p. 222.

~ DĀMODARA’S BĪJAS ~

(83–84) Whatever has elapsed of the *kalī[yuga]* is divided by 180000. The smaller of what has elapsed and what is to come of it [*kalīyuga*] is multiplied [separately] by 1, 2, 3, 24, 22, 30, 90, and 7 [the result corresponding to the seven planets].

[The longitudes of] the Sun, Saturn, and Mars are increased by [the result expressed in] degrees divided by 90000, and [the longitudes of] the others [i.e., the Moon, Mercury, Venus, and Jupiter] are diminished [by it].

The intelligent Dāmodara says that in this way, by means of this [correction], there is true identity with what is observed for the planets.

Jñānarāja here follows a set of *bīja* (literally, seed) corrections given by Dāmodara.²¹ Unfortunately, Dāmodara’s work has not been published.

A *bīja* correction often converts between data from one *pakṣa*, or astronomical school, to another, but is equally often obscure. It is not clear what purpose these *bījas* of Dāmodara serve, or why Jñānarāja chose to include them here.

~ LOCATIONS AND DISTANCES ON THE PRIME MERIDIAN ~

(85–86) Kanyā is located 125 *yojanas* from Laṅkā [to the north]. Kāntī is [north of Kanyā] by 32 [*yojanas*]. Svāmī is [north of Kāntī] by 80 [*yojanas*]. Sagara is [north of Svāmī] by 20 [*yojanas*]. Mallāri is [north of Sagara] by 15 [*yojanas*]. Paryalī is north [of Mallāri] by 8 *yojanas*. The city [of] Vatsagulma is [north of Paryalī] by 10 [*yojanas*]. The city of Ujjayinī is [north of Vatsagulma] by 50 [*yojanas*]. Kurukṣetra is [north of] that [place] by 110 [*yojanas*]. [The mountain] Meru is [north of] that [place] by 825 *yojanas*. In this way the prime meridian of the Earth is explained.

²¹For Dāmodara, see [22.2.125–127].

In Indian astronomy, the prime meridian passes through Ujjayinī (the modern Ujjain in Madhya Pradesh). In other words, the prime meridian is the great circle from the north pole to the south pole that passes through Ujjayinī. These two verses lists a number of locations on the prime meridian, as well as the distance in *yojanas* between two successive locations. The list starts from Laṅkā in the south and proceeds to Meru in the north. Laṅkā is on the terrestrial equator and Meru is on the north pole, so the locations mentioned span exactly one quarter of the Earth's circumference.

The circumference of the Earth is 5059 *yojanas*,²² and thus one quarter of the circumference is $\frac{5059}{4} = 1264\frac{3}{4}$ *yojanas*. However, if we add up the distances given, we get

$$125 + 32 + 80 + 20 + 15 + 8 + 10 + 50 + 110 + 825 = 1275 \quad (3.51)$$

yojanas. We use a rule given in the *tripraśnādhikāra*,²³ according to which the difference between the latitudes of two locations on the same meridian is to be multiplied by 14 to get the *yojanas* between the locations. Using this rule to find the difference in latitude between two locations 1275 *yojanas* apart on the same meridian, we get

$$\frac{1275}{14} = 90\frac{1}{14} \approx 90;4, \quad (3.52)$$

which is fairly close to the expected 90°. Cintāmaṇi makes reference to this rule in his commentary, saying that it can be used to compute the distance between locations on the prime meridian and giving one example.

In some manuscripts, Kanyā is called Devakanyā, and Kāntī and the distance of 32 *yojanas* between Kāntī and Kanyā are omitted. This gives a total of

$$1275 - 32 = 1243 \quad (3.53)$$

yojanas, which is less accurate than the previous total.

~ TO FIND THE LONGITUDINAL CORRECTION ~

(87) The daily motion of the planets is multiplied by the *yojanas* between a city on the prime meridian and the given city, [the two being on the same latitude circle], and divided by the corrected circumference of the Earth. The minutes of arc of the result are applied positively or negatively to the mean planet according to whether the given city is located west or east [of the prime meridian].

As we have seen, the planetary positions computed for a given day correspond to midnight at Laṅkā. If we are on the prime meridian, they will correspond to our midnight as well. However, if

²²See 1.1.74.

²³See 2.3.18.

we are not on the prime meridian, the positions need to be adjusted in order to correspond to our local midnight. The correction that is carried out to achieve this is called the longitudinal correction (*deśāntara*).

Suppose that the given location, P_1 , is d *yojanas* from a location on the prime meridian, P_2 , along a latitude circle (a circle through all locations with the same latitude). If we are not on the terrestrial equator, the circumference of our latitude circle will be smaller than the circumference of the Earth. The circumference of our latitude circle is called the corrected circumference of the Earth, and how it is computed will be explained in the next verse. For now, assume that its circumference is c' . Like the terrestrial equator, the corrected circumference can be thought of as measuring time, its whole circumference corresponding to 60 *ghaṭikās*, i.e., a nychthemeron.

Let $\bar{v}$ be the mean velocity of a given planet. The quantity

$$\bar{v} \times \frac{d}{c'} \quad (3.54)$$

is the distance traveled by the mean planet in the time between midnight on the prime meridian and midnight at the given location. Since the mean velocity of a planet is generally given in minutes of arc per civil day, the result will be in minutes of arc. These minutes of arc are added to the mean longitude of the planet if the given location is west of the prime meridian, because midnight will occur later here than on the prime meridian. Similarly, the minutes of arc are subtracted from the mean longitude of the planet if the given location is east of the prime meridian.

~ TO COMPUTE THE CORRECTED CIRCUMFERENCE OF THE EARTH ~

(88) **The corrected circumference on the Earth is computed by means of the *yojanas* between the given city and the mountain of the gods.**

The circumference of the Earth multiplied by the Sine of the co-latitude and divided by the radius is said to be its [the corrected circumference's] measure.

Let c be the circumference of the Earth and c' the corrected circumference corresponding to the latitude ϕ . Then

$$c' = c \times \frac{\text{Sin}(\bar{\phi})}{R}. \quad (3.55)$$

That this formula is correct is easily seen from Figure 3.3. The figure shows a section of the sphere of the Earth, the horizontal line being the terrestrial equator. The given location, L , has the latitude ϕ . Let r be the radius of the Earth and r' the radius corresponding to the corrected circumference. It is clear from the figure that

$$r' = r \times \cos(\phi) = r \times \sin(\bar{\phi}) = r \times \frac{\text{Sin}(\bar{\phi})}{R}. \quad (3.56)$$

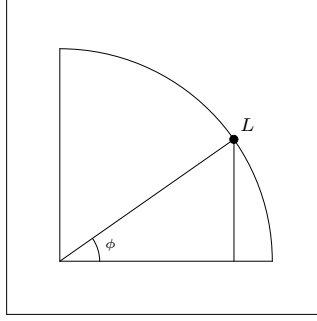


Figure 3.3: Computing the corrected circumference of the Earth for the latitude ϕ

Since $\frac{r'}{r} = \frac{c'}{c}$, we get that

$$c' = c \times \frac{\text{Sin}(\bar{\phi})}{R}, \quad (3.57)$$

which is the formula given in the verse.

~ PRAISE OF THE METHODS PRESENTED ~

(89) That which has been presented by me is very easy and not given by others. Out of a concern of the size in the composing of the *vāsanās*, I condensed it. The wise people who understand the aesthetic abandon what is great and drink the essence, the small circle of the nectar-rayed one [the Moon].

~ CONCLUDING VERSE ~

(90) [Thus] is presented the planets' mean measure in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 4

grahagaṇitādhyaṃya section 2

spaṣṭādhikāra

True motion

~ REASON FOR COMPUTING TRUE PLANETARY POSITIONS ~

(1) Now, when it comes to all auspicious things, [such as] births [of children], performances [of rites], journeys, marriages, and so on, a correct result [arrived at] by means of more correct [positions of the] planets is the most essential thing. Therefore I am describing this method [for accomplishing this].

Based on the positions of the planets, auspicious and inauspicious times for various acts and undertakings can be determined. The mean positions described in the previous chapter are not sufficient for this, and thus the computation of the true positions of the planets is described in this chapter by Jñānarāja.

~ A TABLE OF SINES ~

(2–5) The half-Chords, [i.e.,] the Sines, are, in due order: 225, 449, 671, 890, 1105, 1315, 1520, 1719, 1910, 2093, 2267, 2431, 2585, 2728, 2859, 2978, 3084, 3177, 3256, 3321, 3372, 3409, 3431, and 3438.

The Versed Sines are equal to the sum of the differences of these taken in the opposite order.

The Chords and Sines (with capitalized first letters) mentioned in the verse will be defined below in the commentary.

In modern mathematics, a sine of an angle is the ratio of the side opposite that angle to the hypotenuse in a right-angled triangle (we will refer to this opposite side as the “upright” in the following). Another way of saying this is that modern sines are normalized with respect to a circle of radius 1. In Indian mathematics, on the other hand, sines are given with respect to circles of different radii. It is most often, as here in the *Siddhāntasundara*, a radius of 3438, the last value in the list corresponding to the sine of 90° . This value is used by Āryabhaṭa and in the *Sūryasiddhānta*.¹ Other values are used as well; for example, Brahmagupta uses a radius of 3270 in the *Brāhmasphuṭasiddhānta*, Śrīpati uses a radius of 3415, a value used in the *Vasiṣṭhasiddhānta* as well, and the *Vṛddhavasīṣṭhasiddhānta* has a Sine table with a radius of 1000.²

The choice of the number 3438 as the radius is in many ways a natural one. Suppose that a circle has the radius R . Then its circumference is $2 \times \pi \times R$. As there are 21600 minutes of arc in a circle, the number of minutes of arc per unit of the circumference is $\frac{21600}{2 \times \pi \times R}$. If $R = 3438$, then $\frac{21600}{2 \times \pi \times R} \approx 1$. This means that if the angle α is measured in minutes of arc and is small, then $\text{Sin}(\alpha) \approx \alpha$. Using $R = 3438$ can therefore be compared to our modern use of radians instead of degrees.

In the following, the trigonometric radius 3438 will be called simply “the radius”, and it will be denoted by R in formulae. We will write “Sine” when a sine measured with respect to $R = 3438$ is meant, and similarly $\text{Sin}(\alpha)$ will denote the Sine of the angle α . The relationship between this Sine and the modern sine is $\text{Sin}(\alpha) = R \times \sin(\alpha)$. Similarly, we will write Cosine and $\text{Cos}(\alpha)$; Chord and $\text{Cr}(\alpha)$; and Versed Sine and $\text{Vers}(\alpha)$ to denote the cosine, chord, and versed sine functions based on the radius $R = 3438$. Chords and Versed Sines will be described below and in the commentary to the next verse.

In the Indian tradition, Sines are based on Chords. The Sanskrit words *jīvā* and *ḥjyā* (both literally “bow-string”; a reference to the fact that a chord and its corresponding arc resemble a stringed bow) can mean both “Chord” and “Sine”, and in verse 3, the word *ardhajīvā* is used in the sense of “half-Chord”, while in verse 4, the word *jīvā* is used in the sense of “Sine”.

Now, the verses give a table of the Sine of each of the 24 multiplies of $3^\circ 45'$ between 0° and 90° . Note that since $3^\circ 45' = 225'$, we can also take it that the table gives us the Sine of each of the 24 multiplies of $225'$ between $0^\circ = 0'$ and $90^\circ = 5400'$. Table 4.1 gives the number of each Sine, the corresponding angle, the Sine of the angle, and the modern value of the Sine for comparison. In the following, we will use the notation Sin_n for $\text{Sin}(n \times 3^\circ 45')$ for $n = 1, 2, 3, \dots, 24$, and we will further

¹For Āryabhaṭa, see [71 . 591], and for the *Sūryasiddhānta*, see *Sūryasiddhānta* 2.15–22.

²See *Brāhmasphuṭasiddhānta* 2.2–5; for Brahmagupta’s table of Sines, see [107 . 88]. For Śrīpati, see [71 . 582]. For the *Vasiṣṭhasiddhānta*, see *Vasiṣṭhasiddhānta* 38–42, and see also [71 . 612]. For the *Vṛddhavasīṣṭhasiddhānta*, see *Vṛddhavasīṣṭhasiddhānta* 2.9–10. See also [71 . 612].

Sine number	Angle	Sine	Modern value
1	3°45'	225	224.85
2	7°30'	449	448.74
3	11°15'	671	670.72
4	15°0'	890	889.81
5	18°45'	1105	1105.10
6	22°30'	1315	1315.66
7	26°15'	1520	1520.58
8	30°0'	1719	1719.00
9	33°45'	1910	1910.05
10	37°30'	2093	2092.92
11	41°15'	2267	2266.83
12	45°0'	2431	2431.03
13	48°45'	2585	2584.82
14	52°30'	2728	2727.54
15	56°15'	2859	2858.59
16	60°0'	2978	2977.39
17	63°45'	3084	3083.44
18	67°30'	3177	3176.29
19	71°15'	3256	3255.54
20	75°0'	3321	3320.82
21	78°45'	3372	3371.93
22	82°30'	3409	3408.58
23	86°15'	3431	3430.63
24	90°0'	3438	3438.00

Table 4.1: The *Siddhāntasundara*'s table of Sines

use Sin_0 for $\text{Sin}(0 \times 3^\circ 45') = 0$. Sin_n is thus the n th Sine in the table. It will also be convenient to denote the Sine difference $\text{Sin}_n - \text{Sin}_{n-1}$ by ΔSin_n for $n = 1, 2, \dots, 24$. Similarly, we will define $\text{Cos}_n = \text{Cos}(n \times 3^\circ 45')$.

The versed Sine of an angle α is defined as

$$\text{Vers}(\alpha) = R - \text{Cos}(\alpha) \quad (4.1)$$

The table can be used to compute the versed Sines of the same angles as the Sines by means of the formula

$$\text{Vers}(n \times 3^\circ 45') = \sum_{k=1}^n \Delta\text{Sin}_{25-k} = \sum_{k=1}^n (\text{Sin}_{25-k} - \text{Sin}_{24-k}). \quad (4.2)$$

The formula is straightforward and can be proved as follows:

$$\text{Vers}(n \times 3^\circ 45') = R - \text{Cos}(n \times 3^\circ 45') \quad (4.3)$$

$$= R - \text{Sin}(90^\circ - n \times 3^\circ 45') \quad (4.4)$$

$$= R - \text{Sin}((24 - n) \times 3^\circ 45') \quad (4.5)$$

$$= \text{Sin}_{24} - \text{Sin}_{24-n} \quad (4.6)$$

$$= \sum_{k=1}^n (\text{Sin}_{25-k} - \text{Sin}_{24-k}) \quad (4.7)$$

$$= \sum_{k=1}^n \Delta\text{Sin}_{25-k}. \quad (4.8)$$

Thus far we have only treated a small number of Sines between 0° and 90° . In the following, we will see how to compute the Sine of an angle that is not necessarily a multiple of $3^\circ 45'$ and not limited to being between 0° and 90° .

~ MARKING THE CHORDS ON A CIRCLE ~

(6) On a circle, made up of the minutes of arc in a circle and marked with the 96th parts of the circumference, the Chords are to be drawn lying on both of the two points [among the 96 points] that are on a line running east-west. Accordingly, they are 48. Furthermore, their [corresponding] arcs are to be considered; a versed Sine is lying between the arc and [its corresponding] Chord.

In this and the following verses, Jñānarāja gives a method for how to compute the Sine values given in his table.

The circumference of a circle is divided into 96 equal parts. Two of the points are on the east-west line through the center of the circle. The remaining points are connected in pairs such that

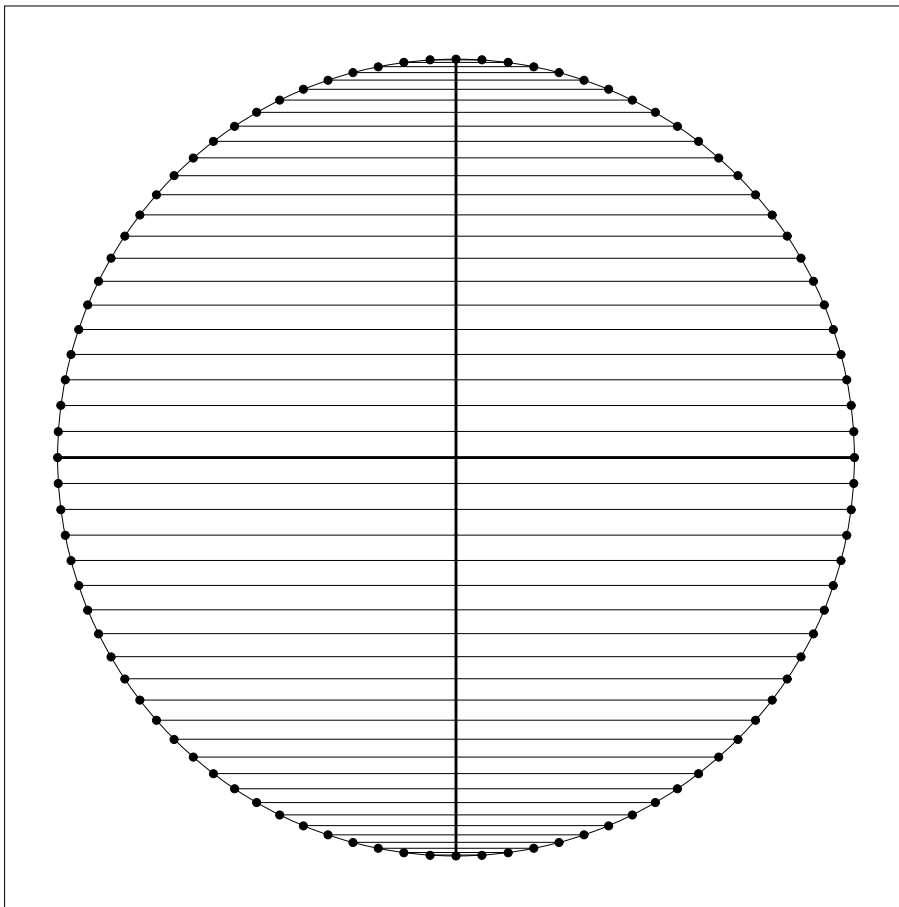


Figure 4.1: 48 Chords from dividing the circumference into 96 parts

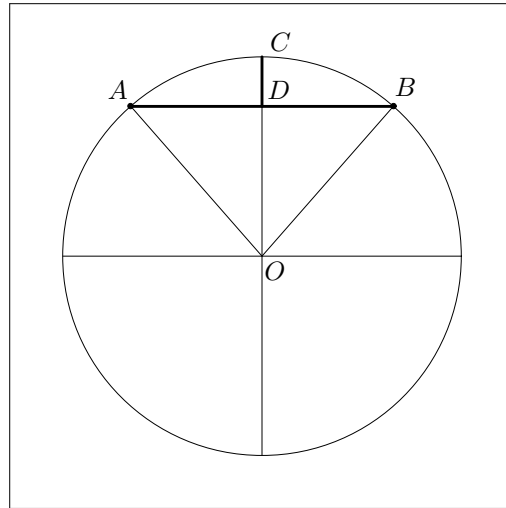


Figure 4.2: The Chord, Sine, and Versed Sine of an angle

the line connecting them is parallel to the east-west line. This is shown in Figure 4.1, where the east-west line is the bold horizontal line. Each horizontal line represents a Chord, namely the Chord of the angle between and above the two lines. There are, of course, 49 such lines, but two of them are merely points, namely the lines connecting the north and south points to themselves. As they yield the Chords of 0° and 360° , which subtend the same point on a circle, they are counted as one. This gives a total of 48 Chords.

The definitions of Chords, Sines, and Versed Sines are seen more clearly on Figure 4.2. The Chord of the arc ACB is the line segment AB , the Sine of $\angle AC$ is the line segment AD , and the Versed Sine of $\angle AC$ is the line segment DC .

~ TO COMPUTE THE SINES OF THE TABLE ~

(7–8) The first half[-Chord] is equal to the 96th part of the minutes of arc in a circle [i.e., 225]. [It is] the leg [in a right-angled triangle], and the [corresponding] hypotenuse is the radius. If the upright is found from these two when the hypotenuse [in this way] is the radius, what is it [the upright] when [the hypotenuse] is equal to 225? The result thus [obtained] is an approximate [value of] the difference between the first Sine and the following one.

[When] the upright is multiplied by 10 and divided by 153, the [Sine] difference is produced. [In other words,] the second [Sine] is produced from the first half[-Chord] increased by that [quantity], and so on like that.

Half of the sum of the traversed [Sine] difference and the current [Sine] difference is the correct Sine difference.

In this way, all the half-Chords are produced in order.

The first Sine, Sin_1 , is equal to 225. This is clear from $\text{Sin}_1 = \text{Sin}(3^\circ 45') = \text{Sin}(225')$ and from the observation, noted in the commentary on verses 2–5, that $\text{Sin}(\alpha) \approx \alpha$ when α , which is measured in minutes of arc, is small.

The difference between Sin_1 and Sin_2 is then found by means of a proportion. Let a right-angled triangle have as its hypotenuse the radius R , and as its leg $\text{Sin}_1 = 225$. The corresponding upright is, of course, $\text{Cos}_1 = \sqrt{R^2 - \text{Sin}_1^2}$. Now, if a similar triangle has a hypotenuse of length 225, the length of its upright is approximately $\text{Sin}_2 - \text{Sin}_1$. Why is that? The upright in question is of length

$$225 \times \frac{\text{Cos}_1}{R} = \frac{\text{Sin}_1}{R} \times \text{Cos}_1. \quad (4.9)$$

That this is approximately equal to $\text{Sin}_2 - \text{Sin}_1$ follows from the following derivation, where we will use the trigonometric relation that $\sin(\alpha) - \sin(\beta) = 2 \times \cos\left(\frac{\alpha+\beta}{2}\right) \times \sin\left(\frac{\alpha-\beta}{2}\right)$ for all α and β :

$$\begin{aligned} \text{Sin}_2 - \text{Sin}_1 &= \frac{1}{R} \times 2 \times \text{Cos}\left(\frac{450' + 225'}{2}\right) \times \text{Sin}\left(\frac{450' - 225'}{2}\right) \\ &= \frac{2 \times \text{Sin}\left(\frac{225'}{2}\right)}{R} \times \text{Cos}\left(225' + \frac{225'}{2}\right) \\ &\approx \frac{2 \times \frac{225}{2}}{R} \times \text{Cos}(225') \\ &= \frac{\text{Sin}_1}{R} \times \text{Cos}_1. \end{aligned} \quad (4.10)$$

Note that since $\text{Cos}(225') = 3430;38$ and $\text{Cos}(225' + \frac{225'}{2}) = 3421;27$, considering these two quantities to be roughly equal is not entirely accurate, but acceptable.

If we are looking at the Sine difference $\text{Sin}_{n+1} - \text{Sin}_n$, the upright mentioned is Cos_n . The formula given for finding the Sine differences is

$$\text{Sin}_{n+1} - \text{Sin}_n = \frac{10}{153} \times \text{Cos}_n \quad (4.11)$$

for $n = 1, 2, \dots, 24$. Noting that

$$\frac{225}{3438} = \frac{10}{153} + \frac{5}{58446} \approx \frac{10}{153}, \quad (4.12)$$

we can derive the given formula by the same procedure as we just followed in the case $n = 1$. In this case, the derivation becomes:

$$\begin{aligned} \text{Sin}_{n+1} - \text{Sin}_n &= \frac{2}{R} \times \text{Cos}\left(\frac{(n+1) \times 225' + n \times 225'}{2}\right) \times \text{Sin}\left(\frac{(n+1) \times 225' - n \times 225'}{2}\right) \\ &= \frac{2 \times \text{Sin}\left(\frac{225'}{2}\right)}{R} \times \text{Cos}\left(n \times 225' + \frac{225'}{2}\right) \end{aligned}$$

$$\begin{aligned}
&\approx \frac{2 \times \frac{225}{2}}{R} \times \text{Cos}(n \times 225') \\
&= \frac{\text{Sin}_1}{R} \times \text{Cos}_n.
\end{aligned} \tag{4.13}$$

As before, it is the approximation $\text{Cos}(n \times 225' + \frac{225'}{2}) \approx \text{Cos}(n \times 225')$ that is the weak point of the derivation. However, the approximation works out reasonably in all cases. Jñānarāja presumably derived the identity differently.

The statement that half of the sum of the traversed Sine difference and the current Sine difference is the true Sine difference means the following. If an angle α satisfies $n \times 3^\circ 45' < \alpha < (n+1) \times 3^\circ 45'$, then the traversed Sine difference is ΔSin_n and the current Sine difference is ΔSin_{n+1} . From the derivation (using the same trigonometric relation as before)

$$\begin{aligned}
\frac{\Delta\text{Sin}_{n+1} + \Delta\text{Sin}_n}{2} &= \frac{\text{Sin}_{n+1} - \text{Sin}_{n-1}}{2} \\
&= \frac{1}{R} \times \text{Cos}\left(\frac{2 \times n \times 225'}{2}\right) \times \text{Sin}\left(\frac{2 \times 255'}{2}\right) \\
&= \frac{\text{Sin}_1}{R} \times \text{Cos}_n \\
&\approx \text{Sin}_{n+1} - \text{Sin}_n \\
&= \Delta\text{Sin}_{n+1},
\end{aligned} \tag{4.14}$$

we get the result stated in the verse. It is, however, an approximation, not an exact result.

~ PRAISE OF THOSE WHO COMPUTE SINES IN THIS WAY ~

(9) **We consider the person who computes all the half-Chords in order from the first half-Chord to be the polestar in the fastening of the motion of the circle of knowers of computation and the circle of stars.**

The polestar remains fixed in the sky while the other stars move. A person who computes the Sines according to Jñānarāja's directions is here compared to the polestar; he fastens the motion of lesser mathematicians.

~ THE SINES IN THE FOUR QUADRANTS OF THE CIRCLE ~

(10) **There are four quadrants in a circle divided into [twelve] signs. In the first quadrant, [which spans the three first signs] beginning with Aries, there is an increase in the Sine [when the angle increases]. In the second [quadrant], there is a decrease. In the third, there is an increase. And in the fourth, there is a decrease in the leg [i.e., in the Sine].**

Like the ecliptic, the circle is here considered to be divided into 12 signs of 30° each, with the sign Aries beginning at 0° . In addition, the circle is divided into four quadrants, the first spanning the first three signs, the second spanning the 4th, 5th, and 6th signs, the third spanning the 7th, 8th, and 9th signs, and the fourth and last spanning the last three signs.

According to Jñānarāja, between 0° and 90° the Sines are increasing. That is, if $0^\circ \leq \alpha < \beta \leq 90^\circ$, then $\text{Sin}(\alpha) < \text{Sin}(\beta)$. Similarly, the Sines are decreasing in the second quadrant, increasing in the third, and finally decreasing in the fourth.

Notice that this differs from the modern sine function, which increases in the first and second quadrants and decreases in the third and fourth quadrants. The reason for this difference is that in the Indian system one always works with positive numbers, and hence every Sine is a positive number. For example, we have $\sin(150^\circ) = -\frac{1}{2}$, but $\text{Sin}(150^\circ) = \frac{1}{2} \times 3438 = 1719$.

More than telling us when the Sine function increases and decreases, the verse indirectly tells us how to compute a Sine in the second, third, and fourth quadrants:

$$\text{Sin}(\alpha) = \begin{cases} \text{Sin}(180^\circ - \alpha) & \text{if } 90^\circ < \alpha \leq 180^\circ, \\ \text{Sin}(\alpha - 180^\circ) & \text{if } 180^\circ < \alpha \leq 270^\circ, \text{ and} \\ \text{Sin}(360^\circ - \alpha) & \text{if } 270^\circ < \alpha \leq 360^\circ. \end{cases} \quad (4.15)$$

In order to be able to compute any given Sine, we only need to be able to compute the Sine of any angle between 0° and 90° . How to do this will be taken up in the next two verses.

~ TO FIND THE SINE OF A GIVEN ANGLE ~

(11) **The complement [of a given arc] is 90 [degrees] diminished by the degrees of the arc. The minutes of arc of those two [quantities] are [separately] divided by 225. The Sine whose number corresponds to [the quotient of] each result is increased by what is attained as a result of the division of the divisor [of the previous division, i.e., 225,] into the remainder [of the previous division] multiplied by the difference between the traversed and current Sines.**

This verse tells us how to compute the Sine and the Cosine of any given angle between 0° and 90° . The method used is simple linear interpolation.

Let α be an angle measured in minutes of arc and satisfying $0' < \alpha < 5400' = 90^\circ$ ($\text{Sin}(0^\circ)$ and $\text{Sin}(90^\circ)$ are known, so we do not need to consider them here). We let $\beta = 5400' - \alpha$, so that β is the complement to the angle α . Since

$$\text{Sin}(\beta) = \text{Sin}(90^\circ - \alpha) = \text{Cos}(\alpha), \quad (4.16)$$

we can find the Cosine of α by computing the Sine of β . The following procedure is meant to be carried out both for α and β , but we will present it only in the case of α .

Let q and r be the quotient and remainder, respectively, of the division of α by 225. Then $\alpha = 225 \times q + r$ where $0 \leq r < 225$. Furthermore, we have that $\text{Sin}_q \leq \text{Sin}(\alpha) < \text{Sin}_{q+1}$. Jñānarāja calls Sin_q the traversed Sine and Sin_{q+1} the present Sine. We can now compute $\text{Sin}(\alpha)$ as

$$\text{Sin}(\alpha) = \text{Sin}_q + \frac{r}{225} \times (\text{Sin}_{q+1} - \text{Sin}_q). \quad (4.17)$$

As noted, this is straightforward linear interpolation.

~ TO FIND THE ANGLE CORRESPONDING TO A GIVEN SINE ~

(12) [Start by] subtracting the [greatest possible] Sine [given in the table from the given Sine]. Whatever is the result of the remainder [of the subtraction of the two Sines] divided by the difference between the traversed and the current Sines, the angle [corresponding to the given Sine] is [equal to] that increased by 225 multiplied by the number [corresponding to] how large the subtracted Sine was.

The Sine table can also be used to find the angle corresponding to a given Sine. As in the previous verse, the method used is simple linear interpolation. The procedure is as follows.

Suppose that we are given the value of a Sine, say $\text{Sin}(\alpha)$, and want to compute the angle α , which is assumed to be between 0° and 90° . We start by finding the greatest positive integer m that satisfies $\text{Sin}_m \leq \text{Sin}(\alpha) < \text{Sin}_{m+1}$. As before, Sin_m is called the traversed Sine and Sin_{m+1} the current Sine. The number corresponding to the Sine that we subtracted, i.e., Sin_m , is m . According to the verse, α can be found as

$$\alpha = 225 \times \frac{\text{Sin}(\alpha) - \text{Sin}_m}{\text{Sin}_{m+1} - \text{Sin}_m} + 225 \times m. \quad (4.18)$$

In this way, we can compute the angle corresponding to any given Sine.

~ A TABLE OF DIFFERENCES OF SMALL SINES AND ITS USE ~

(13–14) The [successive] differences of the small Sines are 25, 24, 23, 21, 19, 16, 13, 10, 6, and 3.

[The procedure for computing the small Sine of a given angle is as follows.] The degrees in the angle are divided by 9. [The quotient of the division] is [the number of] the traversed [small] Sine. The remainder [of the division] is multiplied by the current [small] Sine and divided by 9. [The result is then] increased by the traversed [small Sine] differences. [This is the small Sine of the angle.]

Sine number	Angle	ΔSin_n^ℓ	Sin_n^ℓ	Modern value	Modern difference
1	9°	25	25	25.029	25.029
2	18°	24	49	49.442	24.413
3	27°	23	72	72.638	23.195
4	36°	21	93	94.045	21.407
5	45°	19	112	113.137	19.091
6	54°	16	128	129.442	16.305
7	63°	13	141	142.561	13.118
8	72°	10	151	152.169	9.607
9	81°	6	157	158.030	5.861
10	90°	3	160	160.000	1.969

Table 4.2: The *Siddhāntasundara*'s table of small Sine differences

[The procedure for computing the angle corresponding to a given small Sine is as follows.] One should subtract [as many of] the [small Sine] differences [from the given small Sine as possible]. [When] the result from the division of remainder [of the subtraction process] by the current [small Sine] is increased by 9 multiplied by the number corresponding to the traversed [small Sine], [the result] is the angle.

Jñānarāja here presents another Sine table. It is based on $R = 160$ and a division of the interval between 0° and 90° into 10 equal parts of 9° each. These Sines are called small Sines (*laghujyā*) to distinguish them from the Sines given before in verses 2–5, and we shall use the notation $\text{Sin}^\ell(\alpha)$ to indicate the small Sine of the angle α . We then have that $\text{Sin}^\ell(\alpha) = 160 \times \sin(\alpha)$ if $0^\circ \leq \alpha \leq 90^\circ$. As before, we define Sin_n^ℓ as $\text{Sin}^\ell(n \times 9^\circ)$ for $0 \leq n \leq 10$ and ΔSin_n^ℓ as $\text{Sin}_n^\ell - \text{Sin}_{n-1}^\ell$ for $1 \leq n \leq 10$.

What is tabulated here by Jñānarāja is not small Sines directly, but rather small Sine differences. The numbers tabulated are $\Delta\text{Sin}_1^\ell, \Delta\text{Sin}_2^\ell, \dots, \Delta\text{Sin}_{10}^\ell$. Note that

$$\text{Sin}_n^\ell = \sum_{k=1}^n \Delta\text{Sin}_k^\ell, \quad (4.19)$$

a result that is easily verified.

The reason for including the table of small Sine differences is that these are easier to do computations with than the Sines. The numbers are smaller and there are fewer of them. The values produced by small Sine differences are less accurate than those produced by the Sines, but not significantly so for practical purposes. In the verses containing problems and their solutions in the next chapter, Jñānarāja uses small Sines rather than Sines for his computations.

Table 4.2 gives for each successive small Sine difference its number, its corresponding angle, its value, its corresponding small Sine (not given in the text), the modern value of the small Sine, and the modern value of the small Sine difference.

As with the previous Sine table, this table can be used to compute the small Sine of a given

angle, as well as the angle corresponding to a given small Sine. Yet again, the method used is linear interpolation.

Let there be given an angle, α , and let q and r be the quotient and the remainder, respectively, of the division of α by 9. Then $\alpha = 9 \times q + r$, where $0 \leq r < 9$. Furthermore, q is the number of the traversed small Sine, Sin_q^ℓ , as mentioned in the verses. The small Sine of α can now be found as

$$\text{Sin}^\ell(\alpha) = \frac{r}{9} \times \Delta \text{Sin}_{q+1}^\ell + \sum_{k=1}^q \Delta \text{Sin}_k^\ell. \quad (4.20)$$

Now, if instead of an angle we are given the value of a small Sine, say $\text{Sin}^\ell(\alpha)$, we can find the angle as follows. Let n be the largest possible integer that satisfies that $r = \text{Sin}^\ell(\alpha) - \sum_{k=1}^n \Delta \text{Sin}_k^\ell$ is nonnegative. Put differently, we subtract as many small Sine differences as possible from $\text{Sin}^\ell(\alpha)$. The result is r . Then α can be found as

$$\alpha = \frac{9 \times r}{\Delta \text{Sin}_{n+1}^\ell} + 9 \times n. \quad (4.21)$$

Yet again this is simple linear interpolation.

~ THE MANDA AND ŚĪGHRA ANOMALIES ~

(15) The *manda* anomaly is [defined as the longitude of] the [mean] planet diminished by [the longitude of] the *manda* apogee, [and] the *śīghra* anomaly is [defined as the longitude of] the *śīghra* apogee diminished by [the longitude of] the [mean] planet.

If [either] the *śīghra* or the *manda* anomaly are situated in [the half-circle] beginning with Aries or in [the half-circle] beginning with Libra, the respective equations are a positive and a negative application or a negative and a positive application, respectively.

If the *śīghra* anomaly is situated in [the half-circle] beginning with Aries or in [the half-circle] beginning with Libra, its equation is a positive or a negative application, [respectively]. [Similarly,] if the *manda* anomaly [is situated in the half-circle beginning with Aries or in the half-circle beginning with Libra], [its equation] is a negative or positive application, [respectively].

Having concluded the section on Sines and small Sines, Jñānarāja turns to planetary theory. At this point, it will be instructive to give a brief description of the Indian planetary model.

The planetary model of the Indian tradition is illustrated in Figure 4.3.³ The center of each planetary orbit is the center of the Earth, which is marked by O in the figure. The mean planet,

³See also [71 . 557–558].

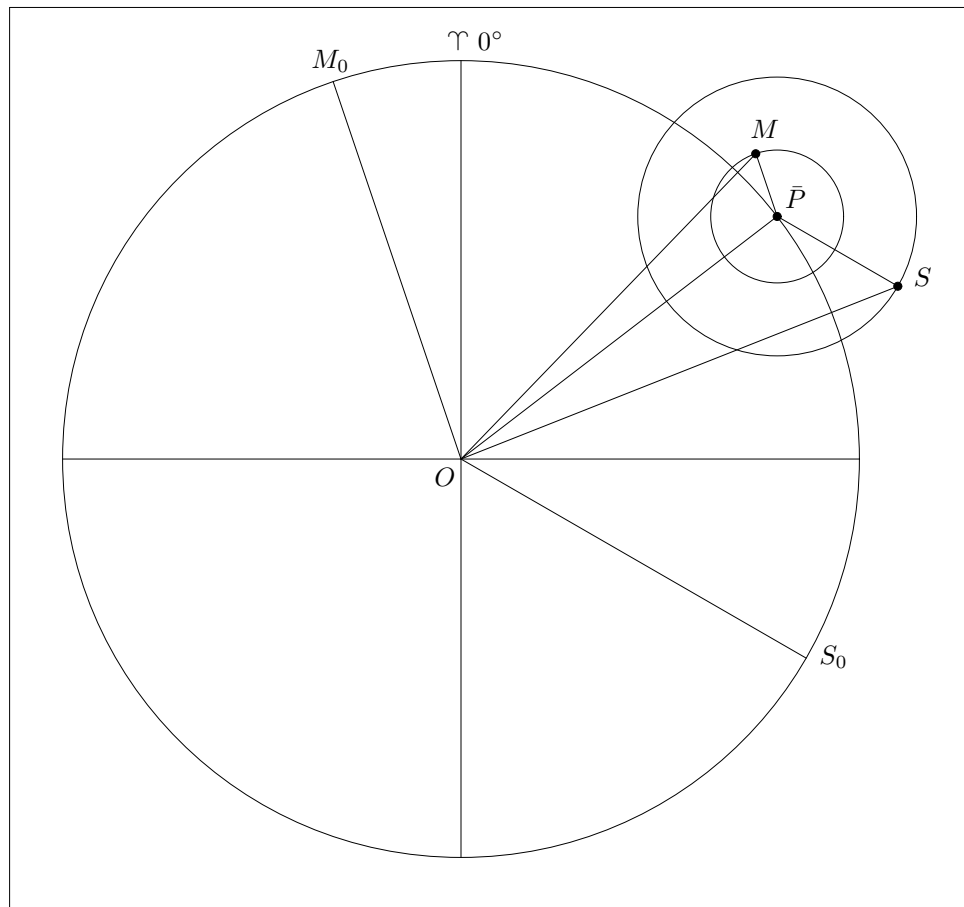


Figure 4.3: The epicyclic model of Indian astronomy

$\bar{P}$, which was described in the previous chapter, rotates around O on the large circle of the figure, called the deferent. The deferent is divided into four quadrants consisting of three signs each, and planetary longitudes are measured from the beginning of Aries, the first of the twelve signs. The beginning-point of Aries is marked as $\Upsilon 0^\circ$ on the figure.

Centered around $\bar{P}$ are, in the case of the five star-planets, two epicycles: the *manda* (slow) epicycle, which is the smaller of the two on the figure, and the *śīghra* (fast) epicycle, which is the larger one. For the Sun and the Moon, there is only one epicycle: the *manda* epicycle. The circumferences of the two vary for each star-planet, but with the exception of Saturn, the *śīghra* epicycle is always larger than the *manda* epicycle.

Associated with each epicycle is an apogee: M_0 in the case of the *manda* epicycle, and S_0 in the case of the *śīghra* epicycle. The point M on the *manda* epicycle and the point S on the *śīghra* epicycle satisfy that the lines $\bar{P}M$ and $\bar{P}S$ are parallel to OM_0 and OS_0 , respectively. The points where the lines OM and OS , extended if necessary, intersect the deferent would be the position of the planet if the respective epicycle acted alone. For the Sun and the Moon, the point of intersection between the line OM and the deferent is the position of the true planet. In the case of the five star-planets, the true planet is found by combining the two epicycles in a manner that will be explained later in the chapter (see verses 23^{c-d}–24).

The *manda* equation of center, or simply equation, is defined as the angle $\bar{P}OM$ and the *śīghra* equation is defined as the angle $\bar{P}OS$. The equation is thus the angle by which the mean planet is displaced by the respective epicycle.

The *manda* anomaly, κ_μ , is defined as the difference between the longitude of the mean planet and the longitude of the *manda* apogee, and the *śīghra* anomaly, κ_σ , is defined as the difference between the longitude of the *śīghra* apogee and the longitude of the mean planet. In both cases, the anomaly is the angle between the respective apogee and the mean planet, and on the figure they are $\angle M_0O\bar{P}$ and $\angle S_0O\bar{P}$, respectively; the difference in the definitions only affects when the equation is to be applied positively or negatively. That the *manda* equation is positive between 0° and 180° and negative between 180° and 360° , while it is opposite for the *śīghra* equation, is clear from the figure and the definitions of the two anomalies.

~ EPICYCLICAL CIRCUMFERENCES FOR CERTAIN ANOMALIES ~

(16–18^b) When the [*manda*] anomaly is at the end of an even quadrant, the degrees of the circumferences in the *manda* epicycle are 14 for the Sun, 32 for the Moon, 75 in the case of Mars, 30 in the case of Mercury, 33 for Jupiter, 12 for Venus, 49 for Saturn.

When the [*manda*] anomaly is at [the end of] an odd quadrant, [the degrees of the circumferences in the *manda* epicycle are] 13;40 for the Sun, 31;40 for the Moon [they are], and 72, 28, 32, 11, and 48 for [the

Planet	<i>Manda</i> anomaly		<i>Śighra</i> anomaly	
	0° and 180°	90° and 270°	0° and 180°	90° and 270°
The Sun	14°	13;40°	—	—
The Moon	32°	31;40°	—	—
Mars	75°	72°	235°	232°
Mercury	30°	28°	133°	132°
Jupiter	33°	32°	70°	72°
Venus	12°	11°	262°	260°
Saturn	49°	48°	39°	40°

Table 4.3: Epicyclical circumferences at the end of quadrants

star-planets] beginning with Mars.

[When the *śighra* anomaly is] at [the end of] an even quadrant, the degrees in the *śighra* epicycle are 235, 133, 70, 262, and 39 for [the star-planets] beginning with Mars.

[When the *śighra* anomaly is] at [the end of] an odd quadrant, [the degrees in the *śighra* epicycle] are 232, 132, 72, 260, and 40 for [the star-planets] beginning with Mars.

The two even quadrants are the second and the fourth, and the two odd quadrants are the first and the third. When the anomaly is at the end of an even quadrant, it is therefore either 0° or 180°. It is similarly either 90° or 270° at the end of an odd quadrant. The circumferences of the epicycles when the anomalies have these values are given in Table 4.3. Note that the circumferences are measured in units of which there are 360 in the deferent, which is why their values are given in degrees.

~ EPICYCLICAL CIRCUMFERENCE FOR A GIVEN ANOMALY ~

(18^{c-d}) [After] the Sine of the anomaly is multiplied by the difference between the circumferences [at the end of even and odd quadrants, respectively,] and divided by the radius, the circumferences [at the end of even quadrants] are diminished or increased by the result according to whether they are greater or less than [the circumferences at the end of] odd [quadrants]. [These are the] true [circumferences].

Let c_2 be the circumference of either the *manda* epicycle or the *śighra* epicycle of a given planet at the end of an even quadrant and let c_1 be the circumference at the end of an odd quadrant. Let d be the difference between c_2 and c_1 , and remember that in the Indian system such a difference is always a positive number. In other words, in our notation we have that $d = |c_2 - c_1|$. Assume

further that the current anomaly is κ . Finally, let b be given by $b = \frac{\text{Sin}(\kappa) \times d}{R}$. Note that b is just a linear interpolation factor.

The epicyclical circumference, c , corresponding to the anomaly κ is given by

$$c = \begin{cases} c_2 - b & \text{if } c_2 > c_1, \text{ and} \\ c_2 + b & \text{if } c_2 < c_1. \end{cases} \quad (4.22)$$

This formula is given in the *Sūryasiddhānta*.⁴

~ TO FIND THE KOTIPHALA AND THE BHUJAPHALA ~

(19) [When] the Cosine and the Sine [of the anomaly] are multiplied by the true circumference and divided by 360, [the two reults] are the *koṭiphala* and the *bhujaphala*.

The arc corresponding to the *manda bhujaphala* is [approximately] the *manda* equation of the planet in minutes of arc.

As noted, the circumference, c , of an epicycle as given in verses 16–18^b is measured in units of which there are 360 in the deferent circle.⁵ Since the circumference of the deferent is $2 \times \pi \times R$, the circumference of a given epicycle, measured in regular units, is $\frac{2 \times \pi \times R}{360} \times c$. Its radius, r , is then

$$r = \frac{1}{2 \times \pi} \times \frac{2 \times \pi \times R}{360} \times c = \frac{c}{360} \times R. \quad (4.23)$$

This shows that the ratio $\frac{c}{360}$ simply converts lengths related to the deferent to the corresponding lengths related to the epicycle.

Now, Figure 4.4 depicts the deferent and an epicycle (let us assume that it is a *manda* epicycle) with apogee A_0 . Let κ be the anomaly, i.e., $\angle A_0 O \bar{P}$. The line AB is drawn so that it is perpendicular to the line OP_0 .

The *bhujaphala* and the *koṭiphala* are, respectively, the line segments AB and BP_0 . It is clear from the figure and from the fact that the factor $\frac{c}{360}$ converts lengths related to the deferent to the corresponding lengths related to the epicycle that the length of the *koṭiphala* is $\frac{c}{360} \times \text{Cos}(\kappa)$ and the *bhujaphala* is $\frac{c}{360} \times \text{Sin}(\kappa)$.

As is customary in the Indian astronomical tradition, Jñānarāja takes the Sine of the *manda* equation to be the length of the *bhujaphala*. As can be easily seen from the figure, this is not correct, for the Sine of the *manda* equation is the length of CD , whereas the *bhujaphala* is the segment AB . However, as the circumferences of the *manda* epicycles are small, it is an acceptable approximation. The circumferences of the *śīghra* epicycles are generally too large for the approximation to be useful.

⁴*Sūryasiddhānta* 2.38. It also given by other astronomers; for example by Brahmagupta in *Brāhmasphuṭa-siddhānta* 2.13.

⁵See [71 . 558].

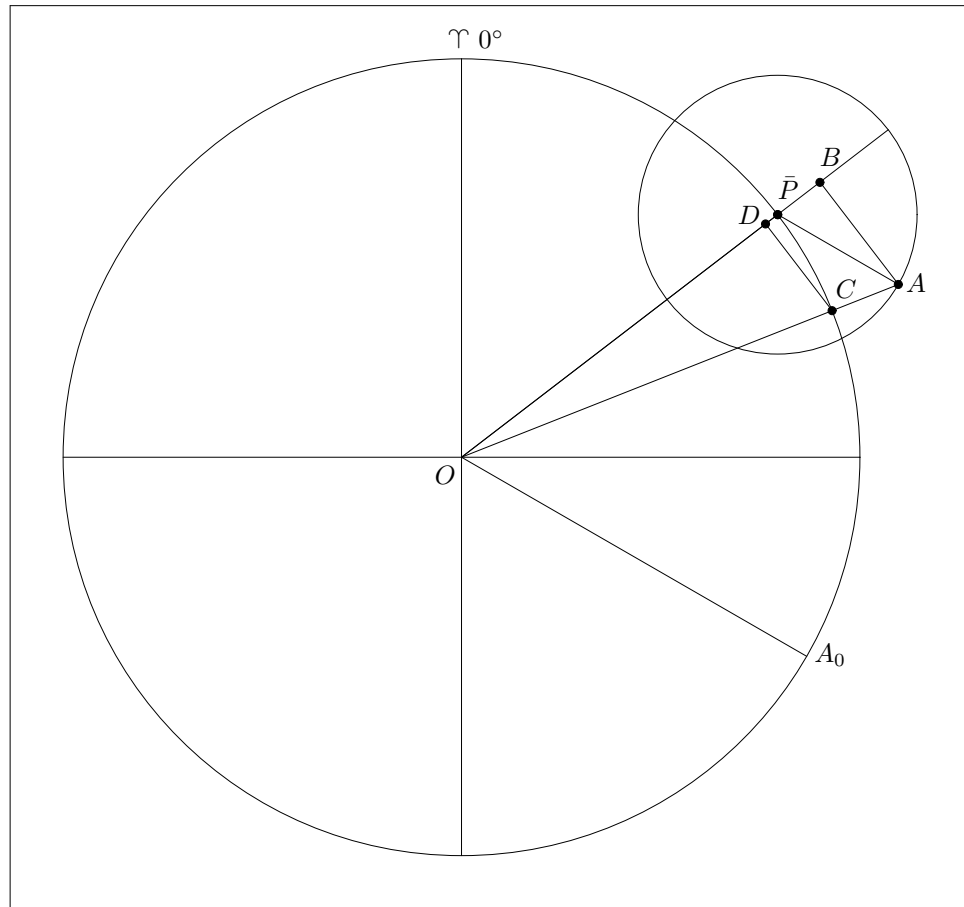


Figure 4.4: The *kotiphala* and the *bhujaphala*

Note that Jñānarāja's use of Sine and Cosine implies that the deferent circle is treated as the standard trigonometric circle. In other words, it is assumed to have a radius of 3438.

~ TO FIND THE BHUJAPHALA USING SMALL SINES ~

(20) Alternatively, the small Sine of the anomaly is multiplied by 4 and divided by 67. The result, in minutes of arc and so on, is multiplied by the [true] circumference [of the epicycle]. [The resulting quantity is the *bhujaphala*.]

For the sake of ease [the arc corresponding to] this [*bhujaphala*] is called the *manda* [equation].

From the previous verse, we know that the *bhujaphala* is equal to $\frac{c}{360} \times \sin(\kappa)$. If we want to express the *bhujaphala* in terms of a small Sine rather than a Sine (that is, to use the radius $R = 160$ rather than the radius $R = 3438$), we need the number x that satisfies $\frac{3438}{360} = \frac{160}{x}$. For then

$$\frac{c}{360} \times \sin(\kappa) = c \times |\sin(\kappa)| \times \frac{3438}{360} = c \times |\sin(\kappa)| \times \frac{160}{x} = c \times \sin^\ell(\kappa) \times \frac{1}{x}, \quad (4.24)$$

and we can express the *bhujaphala* in terms of a small Sine rather than a Sine.

By expanding $\frac{1}{x}$ as a continued fraction, we get

$$\frac{1}{x} = \frac{3438}{360 \times 160} = \frac{191}{3200} = \frac{1}{16 + \frac{1}{1 + \frac{1}{3 + \frac{1}{7}}}} \approx \frac{1}{16 + \frac{1}{1 + \frac{1}{3}}} = \frac{4}{67}, \quad (4.25)$$

from which the formula follows.

~ THE GEOCENTRIC DISTANCE OF THE PLANET ~

(21) The sum or the difference of the radius and the *śīghra koṭiphala*, when the anomaly is in [one of the six signs] beginning with Capricorn or [in one of the six signs] beginning with Cancer, respectively, is to be computed. The square root of the sum of the square of [the result of] that [operation] and the square of the *bhujaphala* is the hypotenuse, measured by the distance between the center of the Earth and the planet.

Figure 4.5 shows two different positions of the *śīghra* epicycle. For each position, a right-angled triangle is formed, namely the triangle $OS'B'$ and the triangle $OS''B''$. In the first case, the radius of the deferent (which is $R = 3438$) is increased by the *koṭiphala*, and the second case, it is decreased by the *koṭiphala*. According to the verse, the *koṭiphala* is added when the anomaly is either between

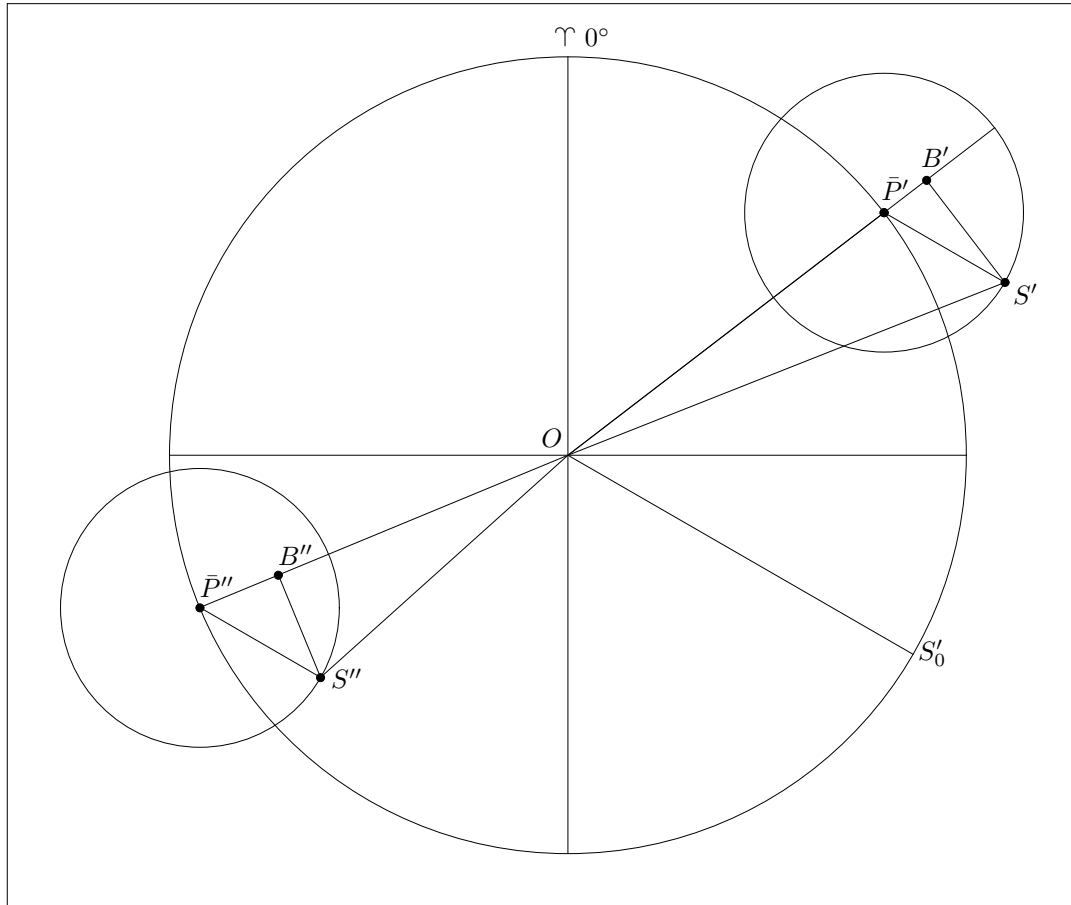


Figure 4.5: Finding the hypotenuse from the *kotiphala* and the *bhujaphala*

0° and 90° or between 270° and 360° , and subtracted when the anomaly is between 90° and 270° . This can be verified easily from the figure.

The hypotenuse (*karṇa*) represents the distance between the center of the Earth and the position the planet would have if the *śīghra* epicycle acted alone on it. Since the *śīghra* epicycle has a much greater effect than the *manda* epicycle, the hypotenuse is roughly the geocentric distance of the planet. If we denote the hypotenuse by H , the *koṭīphala* by k , and the *bhujaphala* by b , then

$$H = \sqrt{(R \pm k)^2 + b^2} \quad (4.26)$$

by the Pythagorean theorem. On the figure, depending on which epicycle we are dealing with, H is the length of OS' or OS'' , k is the length of $B'\bar{P}'$ or $B''\bar{P}''$, and b is the length of $B'S''$ or $B''S''$.

~ TO COMPUTE A SQUARE ROOT ~

(22) An [approximate value of the desired] square root is increased by the result of the division of the given square [i.e., the number whose square root we are seeking] by the approximate square root. [The result] is divided by 2. That is the [new] approximate square root. Then [the process is repeated] again and again. In this way, the correct square root [is found].

The previous verse required the computation of a square root, and so a procedure to carry out such a computation is given in the present verse.

The method works as follows. Suppose that we want to compute the square root of the positive number A . Suppose further that the positive number a_0 is an approximation to $\sqrt{A}$, i.e., that $A - a_0^2$ is small. If we let

$$a_1 = \frac{1}{2} \times \left(a_0 + \frac{A}{a_0} \right), \quad (4.27)$$

then a_1 is a better approximation to $\sqrt{A}$. Continuing this process iteratively by letting

$$a_{n+1} = \frac{1}{2} \times \left(a_n + \frac{A}{a_n} \right) \quad (4.28)$$

for $n = 1, 2, 3, \dots$, we obtain a sequence $a_0, a_1, a_2, \dots, a_n, a_{n+1}, \dots$ of successively better and better approximations to $\sqrt{A}$. When sufficient accuracy has been achieved, that is, when a_n and a_{n+1} are sufficiently close to each other, the process is stopped and the square root is then determined as $\sqrt{A} = a_{n+1}$.⁶

This verse is also found in the *bījagaṇitādhyaṃya*,⁷ from which it has been quoted in the secondary literature.⁸ It is quoted (from the *bījagaṇitādhyaṃya*) by Sūryadāsa in the *Sūryaprakāśa*.⁹

⁶That the sequence always converges, and fast, to $\sqrt{A}$ is well-known from modern mathematics. The method is, in fact, equivalent to applying the Newton-Raphson method to the function f defined by $f(x) = x^2 - A$ for all $x > 0$.

⁷See [43 . 12–13 of Introduction].

⁸See, e.g., [3 . p. 101].

⁹See [43 . 45 of Sanskrit text].

Historical notes regarding this method were given in the Introduction (see p. 44).

(23^{a-b}) The *bhujaphala* is multiplied by the radius and divided by the *śīghra* hypotenuse. The minutes in the arc corresponding to the result of that [operation] is the *śīghra* equation.

$$\text{Sin}(\sigma) = \frac{b \times R}{H}, \quad (4.29)$$

where H is the length of OS and b is the length of BS ; i.e., they are the hypotenuse and the *bhujaphala*, respectively.

~ TO FIND THE TRUE POSITIONS OF THE PLANETS ~

(23^{c-d}-24) The Sun and the Moon are corrected by [one] entire [application of the] *manda* [equation]. The others are corrected by four [applications of] equations.

Having applied half of the [planet's] own *śīghra* equation positively or negatively [as the case may be] to the mean [planet], then half the *manda* equation [found from the new position is applied] to it [i.e., to the new position]. [This gives yet another position.] By [an application to the mean planet of] the entire *manda* [equation] derived from that [position], the mean [planet] becomes *manda*-corrected. [The *manda*-corrected planet] becomes [the] true [planet] by [an application of] the entire *śīghra* [equation].

The Sun and the Moon have only one epicycle each, namely the *manda* epicycle. To get their true positions, one need only apply (that is, add or subtract, as the situation may be) the *manda* equation to the mean position. This is clear and simple.

The five star-planets, on the other hand, have two epicycles, the *manda* epicycle and the *śīghra* epicycle. From Figure 4.3 on p. 147 it may appear as if the two epicycles are independent, but in reality they are not. They need to be combined, but how to do so is not obvious. The procedure followed by Jñānarāja consists of four applications of equations.

First, half of the *manda* equation is applied to the mean planet. This gives a new position. Next, half of the *śīghra* equation computed from the new position is applied to the new position. Then the *manda* equation computed from that position is applied to that position, at which point the planet is called *manda*-corrected. Finally, the entire *śīghra* equation is applied to the *manda*-corrected planet, which gives the true position of the planet. This is the same procedure as given in the *Sūryasiddhānta*.¹⁰

For a recent discussion of the rationale behind this procedure, see [23].

~ PROCEDURE TO FIND THE TRUE POSITION OF A STAR-PLANET ~

(25) The *śīghra* equation computed from [the mean planet corrected by] the entire *manda* equation is not correct. First, the *manda*-corrected [planet] is to be known from the mean planet only. Then, the *manda* equation produced from the mean [planet] corrected by half of the *śīghra* equation and [half of] the *manda* equation is correct. [That is] sufficient. What is strange in this procedure?

¹⁰*Sūryasiddhānta* 2.43–44.

The verse restates the procedure previously given, adding that it is incorrect to merely apply the whole *manda* equation and then the whole *śīghra* equation to get the true planet.

~ TO FIND A PLANET'S TRUE VELOCITY ~

(26–28) The velocity of the *manda* anomaly is [first] multiplied by the difference of the Sines [i.e., the difference between the current Sine and the previous Sine], [next] divided by the first half-Chord, [then] multiplied by the true circumference, [and finally] divided by the degrees in a rotation [i.e., by 360]. [This is] the result for the *manda* velocity.

The [mean] velocity [of a planet] diminished or increased by that result, according to whether the [*manda*] anomaly is in [one of the six signs] beginning with Capricorn or in [one of the six signs] beginning with Cancer, is *manda*-corrected.

Having subtracted that [*manda*-corrected velocity] from the velocity of the *śīghra* apogee, the remainder is the motion produced by *śīghra* anomaly.

In the case of the [effect of the] course of the arc of the *śīghra* equation [on the velocity], this [remainder] is multiplied by the difference of the Sines [i.e., the difference between the current Sine and the previous Sine] and divided by the first Sine. [Then the result is] divided by the [*śīghra*] hypotenuse and multiplied by the radius. [The resulting quantity] is subtracted from the velocity of the *śīghra* apogee, [yielding] the true velocity [of the planet].

Let κ_μ and κ_σ be the *manda* anomaly and the *śīghra* anomaly, respectively. Let v_κ and w_κ be the velocities of the *manda* anomaly and the *śīghra* anomaly (i.e., the rate by which each changes during a civil day), respectively. Assume further that $n \times 3^\circ 45' \leq \kappa_\mu < (n+1) \times 3^\circ 45'$. Then Sin_{n+1} is the current Sine and Sin_n is the previous Sine in the case of the *manda* anomaly.

The mean planet moves at a constant velocity, but due to the effects of the epicycles (or epicycle, in the case of the luminaries), the velocity of the true planet, i.e., the true velocity, changes over time. Both the *manda* epicycle and the *śīghra* epicycle contribute to this.

In order to find the effect of the *manda* epicycle on the velocity, the following quantity is computed:

$$u = v_\kappa \times \frac{\text{Sin}_{n+1} - \text{Sin}_n}{\text{Sin}_1} \times \frac{c}{360}. \quad (4.30)$$

Why u has this form is not clear.¹¹ This is to be applied to the mean velocity to get the velocity after the effect of the *manda* epicycle has been applied.

If the *manda* anomaly is in one of the six signs beginning with Capricorn, i.e., if it is between 270° and 360° or between 0° and 90°, the displacement of the mean planet by the *manda* epicycle has the effect that the true velocity is smaller than the mean velocity. Therefore, the *manda*-corrected velocity, v_m , in this case is

$$v_m = \bar{v} - u. \quad (4.31)$$

If the *manda* anomaly is in one of the six signs beginning with Cancer, i.e., if it is between 90° and 270°, it is opposite, so that

$$v_m = \bar{v} + u. \quad (4.32)$$

Assume that $m \times 3^\circ 45' \leq \kappa_\sigma < (m+1) \times 3^\circ 45'$. Then Sin_{m+1} is the current Sine and Sin_m is the previous Sine in the case of the *śīghra* anomaly.

Let w_σ be the velocity of the *śīghra* apogee and H the hypotenuse (i.e., the geocentric distance of the planet). The correction to the velocity due to the *śīghra* epicycle is computed as follows:

$$u' = (w_\sigma - v_m) \times \frac{\text{Sin}_{m+1} - \text{Sin}_m}{\text{Sin}_1} \times \frac{R}{H} \quad (4.33)$$

The form of u' is also not clear.¹² If this quantity is smaller than the velocity of the *śīghra* apogee, then the true velocity of the planet, v , is

$$v = w_\sigma - u'. \quad (4.34)$$

However, if it is larger, then the planet is in retrograde motion with the velocity

$$v = u' - w_\sigma. \quad (4.35)$$

This will be taken up in the following by Jñānārāja.

~ CONDITIONS FOR RETROGRADE MOTION ~

(29–31) **When that [correction due to the *śīghra* epicycle] cannot be subtracted [from the *manda*-corrected velocity due to the latter being smaller than the former] it is subtracted inversely [i.e., the former is subtracted from the latter], and the remainder [of that subtraction] is the retrograde velocity of the [star-]planets.**

It has been said by the great ancients that [since] the Sun and the Moon has no *śīghra* epicycles, therefore [they] never [have] retrogradation.

¹¹See [71 . 569].

¹²See [71 . 569].

Planet	First station	Second station
Mars	164°	196°
Mercury	144°	216°
Jupiter	130°	230°
Venus	163°	297°
Saturn	115°	245°

Table 4.4: *Śighra* anomalies at the occurrences of the first and second stations

[When] a [star-]planet that is located very far from its *śighra* apogee commences [its] retrograde motion, then, starting with Mars, these are the degrees of the *śighra* anomaly: 164, 144, 130, 163, and 115.

The degrees at which [the star-planets commence their] direct motion are 360 [degrees] diminished by those.

The degrees and minutes of arc greater or less than [these] given values [for the occurrence of the first station] divided by the velocity of the [*śighra*] anomaly are the days that have elapsed since or are to pass until [the previous or the next station].

For retrogradation and the stations of the star-planets, see the commentary on 2.1.39.

When the correction to the velocity due to the *śighra* epicycle cannot be subtracted from the *manda*-corrected motion, the direction of the motion is opposite the usual direction, i.e., the planet is in retrograde motion. In this case, one subtracts the *manda*-corrected velocity from the *śighra* correction and notes that the planet is retrograde.

The occurrences of the stations are determined by the *śighra* anomalies. Table 4.4 gives the values of the *śighra* anomalies at which each star-planet reaches its first and second stations. These values are the same as those given in the *Sūryasiddhānta*.¹³

If we want to compute the time elapsed since the last occurrence of the first station or the time to pass before the next occurrence of the first station, Jñānarāja tells us to take the angular distance between the current location and the past or future occurrence of the first station and divide by the velocity of the *śighra* anomaly. This is a straightforward formula.

~ THE BHUJĀNTARA CORRECTION ~

(32^{a-b}) The *manda* equation of the Sun [*bāhuphala*] is multiplied by the velocity [of a given planet] and divided by the minutes of arc in all the *nakṣatras* [i.e., by 21600]. [The result] is applied positively or negatively to the [longitude of the given] planet according to [whether] the equation

¹³*Sūryasiddhānta* 2.53–54. See also [71, 610].

[of the Sun [*doḥphala*] is to be applied positively or negatively]. From this is [found the longitude of the given planet] at the rising of the true Sun.

The words *bāhuphala* and *doḥphala* must here refer to the *manda* equation of the Sun. If so, the formula is for computing what is known as the *bhujāntara* in Indian astronomy.¹⁴

In treatises following a sunrise system, the computed planetary positions correspond to the rising of the mean Sun. In order to find their longitudes when the true Sun is rising, the *bhujāntara* correction is applied. However, the inclusion of the formula in this form is somewhat curious, as Jñānarāja follows a midnight system, not a sunrise system.

The *nakṣatras* are constellations in the path of the Moon. Together they span 360° and thus contain 21600′.

~ TO FIND THE SUN'S DECLINATION ~

(32^{c-d}) The Sine produced from the precessional [longitude of the] Sun is multiplied by the Sine of 24 [degrees] and divided by the radius. [The result] is the Sine of the declination [of the Sun]. The arc corresponding to this [Sine] is the declination [of the Sun] having the direction of the hemisphere [that the Sun is in].

Let δ and λ^* be the declination of the Sun and the precessional longitude of the Sun, respectively. For the formula given here,

$$\sin(\delta) = \frac{\sin(\lambda^*) \times \sin(\varepsilon)}{\sin(90^\circ)} = \frac{\sin(\lambda^*) \times \sin(\varepsilon)}{R}, \quad (4.36)$$

see the commentary on 2.1.29^{b-d}. If the Sun is north of the celestial equator, the direction of the declination is north, and similarly if the Sun is south of the celestial equator.

Note that precessional longitude of the Sun (or another planet) is simply the tropical longitude, i.e., the longitude with reference to the vernal equinox.

~ ANOTHER FORMULA FOR THE DECLINATION OF THE SUN ~

(33) [First] the Sine of the precessional [longitude of the] Sun is increased by [its own] sixty-first part, and [then the result is] divided by 10. Good people call this [quantity] multiplied by 4 the Sine of the declination.

The word *anupamaṇa* in the verse is unclear to me, and it is not included in the above translation. Perhaps it means that the Sine of the declination is matchless, though this makes

¹⁴See, e.g., *Brāhmasphuṭasiddhānta* 2.29 and *Śiṣyadhīvrddhidatantra* 2.16. See also [71.569].

little sense. It is also possible that it means that this simplified formula gives a perfectly good approximation. At any rate, the formula given is clear.

This formula is a simplified one for computing the declination of the Sun, namely

$$\text{Sin}(\delta) = 4 \times \frac{\text{Sin}(\lambda^*) + \frac{1}{61} \times \text{Sin}(\lambda^*)}{10} = \frac{124}{305} \times \text{Sin}(\lambda^*), \quad (4.37)$$

where δ is the declination of the Sun, and λ^* is the tropical longitude of the Sun. It is derived from the previous one by the following approximation:

$$\frac{\text{Sin}(\varepsilon)}{R} = \frac{1397}{3438} = \frac{124}{305} - \frac{227}{1048590} \approx \frac{124}{305}. \quad (4.38)$$

~ TO FIND RADIUS OF THE DIURNAL CIRCLE, ETC. ~

(34) **The square root of the difference between the square of the radius and the square of the Sine of the declination [of the Sun] is the radius of the [Sun's] diurnal circle. The Sine of the declination [of the Sun] multiplied by the noon equinoctial shadow and divided by 12 is the earth-Sine. The earth-Sine divided by the radius of the [Sun's] diurnal circle and multiplied by the radius is the Sine of the ascensional difference. The arc of that [Sine of the ascensional difference] is the rising and setting ascensional difference. [The existence] of these two [i.e., the rising and setting ascensional differences] is the difference between [a region] without latitude and [a region] with latitude, [for there is no ascensional difference in the former].**

The formulae given here and the similar triangles that they are based on will be discussed in greater detail in the next chapter. Definitions and further details will be given there (see verses 2.3.6–11 and commentary).

Let r be the radius of the Sun's diurnal circle and δ the declination of the Sun. Then

$$r = \sqrt{R^2 - (\text{Sin}(\delta))^2} \quad (4.39)$$

If s_0 is the equinoctial shadow at noon in a given location and e the Earth-Sine, then

$$e = \text{Sin}(\delta) \times \frac{s_0}{12}. \quad (4.40)$$

Let ω be the ascensional difference. Then

$$\text{Sin}(\omega) = e \times \frac{R}{r}. \quad (4.41)$$

Clearly, the arc corresponding to $\text{Sin}(\omega)$ is the ascensional difference. The existence of the ascensional difference distinguishes regions not on the terrestrial equator from those on it, which do not have ascensional difference at any time.

~ TO CORRECT FOR THE ASCENSIONAL DIFFERENCE ~

(35^{a-b}) The true velocity of a planet is multiplied by the *palas* in the ascensional difference and divided by 60. The seconds of arc attained [as the result] are [applied] positively or negatively to [the true longitude of] the planet depending on whether it is at the rising or the setting of the Sun as well as on which of the two hemispheres we are in.

The ascensional difference will be denoted by ω in the following. As it lies on the equator, it is measured in units of time.

Let v be the true velocity of a given planet, and ω the ascensional difference. In order to compute a planet's true longitude at local sunrise or sunset, Jñānarāja tells us to compute the quantity

$$\frac{v \times \omega}{60}. \quad (4.42)$$

The true velocity of the planet v is measured in minutes of arc per civil day, but when divided by 60, it becomes minutes of arc per *ghaṭikā*. Multiplied by an ascensional difference ω measured in *palas*, the result is measured in seconds of arc. This is the angular distance traveled by the planet during the period of time of the ascensional difference.

Depending on whether we are at sunrise or sunset, as well as what hemisphere we are in, the result is to be added or subtracted from the longitude of the true planet. Although not mentioned here, we also need to take into account whether the Sun is north or south of the celestial equator.

If the true longitude of the planet that we started with corresponds to the planet's position when the Sun rises or sets on the equator, the result will give us the true longitude of the planet at sunset or sunrise at our given location.

~ TO FIND THE DURATION OF DAY AND NIGHT ~

(35^{c-d}) In the northern hemisphere, half of the day and half of the night are said by the knowers of the sphere to be[, respectively,] 15 *ghaṭikās* increased or decreased by the ascensional difference, [depending on whether the Sun is north or south of the celestial equator]. It is opposite in the southern [hemisphere].

On the terrestrial equator, day and night always have equal durations. In other regions, there will be a difference depending on the ascensional difference. When the Sun is above the celestial equator, the days will be longer than the nights in the northern hemisphere. The length of half a day in this case is exactly 15 *ghaṭikās* (the constant length of half a day on the celestial equator) increased by the ascensional difference, and the length of a night is 15 *ghaṭikās* diminished by the ascensional difference. It is opposite when the Sun is below the celestial equator. It is further clear, that the whole scheme is inverted when we are in the southern hemisphere.

~ TO COMPUTE TITHI AND KARAṆA ~

(36) The degrees of [the longitude of] the Moon diminished by [the longitude of] the Sun are divided separately by 12 and 6. [The two results are, respectively,] the elapsed *tithis* and the elapsed *karaṇas*. The *ghaṭikās* [since the last *tithi* or *karaṇa* or until the next *tithi* or *karaṇa* is found] from the remainder as well as the respective divisor by means of a proportion.

A *tithi* is the time during which the Moon gains 12° over the Sun; a *karaṇa* is similarly the time during which the Moon gains 6° over the Sun, i.e., half a *tithi*.¹⁵ As such there are 30 *tithis* and 60 *karaṇas* in a lunar month. The formula given for computing the elapsed *tithis* or *karaṇas* is straightforward, as is the outline given for computing the time since the last *tithi* or *karaṇa* or until the next *tithi* or *karaṇa*.

~ TO FIND THE CURRENT KARAṆA ~

(37) The [number of the current] *karaṇa* is diminished by 1. The [number which is the] remainder [from this number divided] by 7 [tells us which movable *karaṇa* is the current one]. [If the current *karaṇa* is not movable,] the four fixed [*karaṇas*], Śakuni, Catuṣpada, Nāga, and so on, [which begins] from the second half of the 14th *tithi* of the dark [*pakṣa*], are to be added.

The 60 *karaṇas* of a lunar month are numbered starting with 1, and they are further given names. Table 4.5 shows the relationship between the numbers and names of the *karaṇas*.¹⁶ Bava, Bālava, Kaulava, Taitila, Gara, Vaṇij, and Viṣṭi, which occur in that order 7 times in a row, are called movable (*adhruva* or *cara*), and Śakuni, Catuṣpada, Nāga, and Kṁstughna, which are near conjunction, are called fixed (*dhruva* or *sthira*). It is clear from the table that Śakuni begins in the middle of the 14th *tithi* of the dark *pakṣa*, for this *tithi* consists of the 57th and the 58th *karaṇas*.

Suppose that the number of the current *karaṇa* is k and that $1 < k < 58$. Let r be the remainder from the division of $k - 1$ by 7. If $r = 1$, the current *karaṇa* is Bava; if $r = 2$, it is Bālava; and so on. In other words, except for $r = 0$, which indicates Viṣṭi, r directly gives the number of the movable *karaṇa* that is current.

If k is one of 1, 58, 59, or 60, the current *karaṇa* is one of the four fixed *karaṇas*. Their order and appearance in a lunar month is described in the verse.

That the verse is elliptical is evident from the large amount of bracketed text in the translation.

¹⁵For *karaṇas*, see [71 . 546].

¹⁶The table is based on [71 . 546, Table III.18].

<i>Karaṇa</i> number								Name
1								Kimstughna
2	9	16	23	30	37	44	51	Bava
3	10	17	24	31	38	45	52	Bālava
4	11	18	25	32	39	46	53	Kaulava
5	12	19	26	33	40	47	54	Taitila
6	13	20	27	34	41	48	55	Gara
7	14	21	28	35	42	49	56	Vañij
8	15	22	29	36	43	50	57	Viṣṭi
							58	Śakuni
							59	Catuṣpada
							60	Nāga

Table 4.5: Numbers and names of the *karaṇas*

~ TO COMPUTE THE NAKṢATRA AND THE YOGA ~

(38) The degrees of [the longitude of] the Moon and the degrees of [the longitude of] the Moon increased by [the longitude of] the Sun are separately multiplied by 3 and divided by 40. [The two results are, respectively,] the *nakṣatra* and the *yoga*.

Having subtracted the remainder [of any of the two above quantities] from 800, that [result] is [first] multiplied by 20, [then] multiplied by 60, [and finally] divided by the appropriate velocity [depending on whether we are working with the *nakṣatra* or the *yoga*]. [This is] the respective *ghaṭikās* [to elapse before the commencement of the next *nakṣatra* or *yoga*].

In addition to being divided into 12 signs, the ecliptic is also divided into 27 *nakṣatras*, which are sometimes translated as “lunar mansions”. The first *nakṣatra* starts at Aries 0°, and each spans $\frac{360^\circ}{27} = 13^\circ 20' = 800'$.

The word *nakṣatra* here refers to the period of time it takes the Moon to traverse a *nakṣatra*, i.e., to travel 800'. Similarly, a *yoga* is a period of time during which the sum of the distances traveled by the Sun and the Moon equals 800'.

In the following, let $\lambda_\odot$ and λ_ζ be the longitudes of the Sun and the Moon, respectively.

Since longitudes are measured in minutes of arc per civil day and $\frac{800}{60}$ is the length of a *nakṣatra* in degrees, it is clear that

$$\frac{60}{800} \times \lambda_\zeta = \frac{3}{40} \times \lambda_\zeta \quad (4.43)$$

determines the *nakṣatra*, the integer part giving the current *nakṣatra* and the fractional part the position of the Moon in that *nakṣatra*.

Completely analogously, the *yoga* is determined as

$$\frac{60}{800} \times (\lambda_\odot + \lambda_\zeta) = \frac{3}{40} \times (\lambda_\odot + \lambda_\zeta). \quad (4.44)$$

The remainder, i.e., the fractional part, of either $\frac{3}{40} \times \lambda_{\zeta}$ or $\frac{3}{40} \times (\lambda_{\odot} + \lambda_{\zeta})$ gives, respectively, the minutes of arc that have been traversed since the start of the current *nakṣatra* or *yoga*; if the remainder is subtracted from 800', we get the minutes of arc to be traversed before the start of the next *nakṣatra* or *yoga*. If this is multiplied by 60 and divided by the appropriate velocity (v_{ζ} in the case of a *nakṣatra*, and $v_{\odot} + v_{\zeta}$ in the case of a *yoga*), we get the *ghaṭikās* to elapse before the start of the next *nakṣatra* or *yoga* (we can similarly get the *ghaṭikās* elapsed since the start of the current *nakṣatra* or *yoga*, but Jñānarāja does not mention this in the verse). The reason for the multiplication by 20 prescribed in the verse is not clear to me.¹⁷

~ RISING TIMES OF THE SIGNS ~

(39–40) Since the beginning and end points of a sign do not rise at the same place on the horizon on account of the obliqueness of the ecliptic, therefore the rising [times] of the signs are not the same.

[First] the difference between the square of the Sine of 1, 2, and 3 signs [taken separately] and the square of the Sine of the [Sun's] declination [is to be computed]. The square root [of each result] multiplied by the radius is divided by the radius of the [Sun's] diurnal circle. The arcs corresponding to the results [treated as Sines] are diminished by their respective preceding arc[, if it exists], and thus the rising [times] of [all] the signs, [being these 3 rising times] placed in regular and inverted order, are attained for a city on the terrestrial equator.

For a given location, the rising [times of the six first signs for a location on the terrestrial equator] are diminished or increased by the ascensional differences corresponding to [the Sun's precessional longitude being] 1, 2, and 3 signs in the right order [in the case of the three first signs] and put down inversely [in the case of the next three signs]. [The rising times] are inverted for the six [signs beginning] from Libra.

In the above translation, I have taken the word *kutas* in the sense of *yatas*.

For $k = 1, 2, 3$ compute

$$a_k = \frac{R \times \sqrt{(\text{Sin}(k \times 30^\circ))^2 - (\text{Sin}(\delta_k))^2}}{\text{Cos}(\delta_k)}, \quad (4.45)$$

where δ_1 , δ_2 , and δ_3 are the declinations of the Sun when its precessional longitude is 30° , 60° , and 90° , respectively. $\text{Cos}(\delta_k)$ is the radius of the Sun's diurnal circle when the precessional longitude of

¹⁷The *Vaṭeśvarasiddhānta* (2.6.2) likewise multiplies by 20.

Sign	Rising time on the equator	Rising time elsewhere
Aries	τ_1	$\tau_1 - \omega_1$
Taurus	τ_2	$\tau_2 - \omega_2$
Gemini	τ_3	$\tau_3 - \omega_3$
Cancer	τ_3	$\tau_3 + \omega_3$
Leo	τ_2	$\tau_2 + \omega_2$
Virgo	τ_1	$\tau_1 + \omega_1$
Libra	τ_1	$\tau_1 + \omega_1$
Scorpius	τ_2	$\tau_2 + \omega_2$
Sagittarius	τ_3	$\tau_3 + \omega_3$
Capricornus	τ_3	$\tau_3 - \omega_3$
Aquarius	τ_2	$\tau_2 - \omega_2$
Pisces	τ_1	$\tau_1 - \omega_1$

Table 4.6: Rising times of the signs

the Sun is δ_k . The correctness of the formula, which is also given by Bhāskara II in the *Siddhānta-śiromaṇi*,¹⁸ can easily be shown using spherical geometry.

After computing a_1 , a_2 , and a_3 , we treat each as a Sine and find the corresponding arcs, α_1 , α_2 , and α_3 . In other words, $a_k = \text{Sin}(\alpha_k)$ for $k = 1, 2, 3$. Note that α_1 , α_2 , and α_3 are the right ascensions of the three arcs of length 30° , 60° , and 90° measured from the vernal equinox (i.e., the longitudes of the endpoints of these arcs measured with respect to the celestial equator).

Finally, let

$$\tau_1 = \alpha_1, \quad (4.46)$$

$$\tau_2 = \alpha_2 - \alpha_1, \text{ and} \quad (4.47)$$

$$\tau_3 = \alpha_3 - \alpha_2. \quad (4.48)$$

Then $\tau + 1$, τ_2 , and τ_3 are the rising times of Aries, Taurus, and Gemini, respectively, for a location on the terrestrial equator. To find the rising times for all the signs for such a location, we have to place these three in regular and inverted order, as prescribed by Jñānarāja. This is most easily explained by looking at Table 4.6, the second column of which gives the rising time of each sign for a location on the terrestrial equator. It is easy to compute τ_1 , τ_2 , and τ_3 , but Jñānarāja does not give their values.

Now, if we are not on the terrestrial equator, the rising times will be different due to the ascensional difference. Let ω_1 , ω_2 , and ω_3 be the ascensional differences at the given location corresponding to the Sun having the declinations 30° , 60° , and 90° . The rule for taking the ascensional differences into account is illustrated by the third column of Table 4.6 (the inverted order of the last six signs is reflected in when we add and subtract the ascensional differences).

¹⁸*Siddhāntaśiromaṇi*, *gaṇitādhyaṃya*, *spaṣṭādhikāra*, 54–55.

~ DIFFERENCES OF DECLINATIONS ~

(41) First, [since] they are located very obliquely by a difference of declinations equal to 11;45 degrees, the rising of Aries and Pisces [occur] in very few *palas*. The risings of Taurus and Aquarius [occur] by a difference of declinations equal to 9 degrees. Being located at a difference of declinations equal to 4 degrees, [the risings] of Gemini and Capricornus [occur] by many [*palas*].

Let again δ_1 be the declination of the Sun when its precessional longitude is 30° , δ_2 the declination of the Sun when its precessional longitude is 60° , and δ_3 the declination of the Sun when its precessional longitude is 90° .

Then

$$\text{Sin}(\delta_1) = \frac{\text{Sin}(30^\circ) \times \text{Sin}(24^\circ)}{R} = \frac{1719 \times 1397}{3438} = 698\frac{1}{2}, \quad (4.49)$$

and by the formula given in verse 12,

$$\delta_1 = \frac{1}{60} \times \left(225 \times \frac{\text{Sin}(\delta_1) - \text{Sin}_3}{\text{Sin}_4 - \text{Sin}_3} + 3 \times 225 \right) = \frac{6845}{584} \approx 11;45^\circ \quad (4.50)$$

(the division by 60 is carried out in order to get a result in degrees). This agrees with what is given in the verse.

Similarly,

$$\delta_2 = \frac{101573597}{5414850} \approx 18;46, \quad (4.51)$$

but $18;46 - 11;45 = 7;1$, whereas the verse has 9. However, a calculation using a modern calculator gives $\delta_2 = 20;37$, and since $20;37 - 11;45 = 8;52$, this is in better agreement with Jñānarāja's data.

Finally, since δ_3 is the declination of an arc of 90° , it is obvious that $\delta_3 = \varepsilon = 24^\circ$. As $24 - 18;46 = 5;14$, this result also deviates from Jñānarāja's numbers. Using the value of δ_2 arrived at by a modern calculation, however, we get $24 - 20;37 = 3;23$, which is closer to Jñānarāja's data.

It appears that Jñānarāja was able to compute a better value of δ_2 than what the method of verse 12 gives us. His value is, in fact, better than we found, which could imply that he used a better method for computing it or took the number from another source.

The numbers corresponding to the remaining six signs can easily be inferred.

~ TO FIND THE RISING ARCS ~

(42^{a-b}) [If, in three separate right triangles,] the Sines of the endpoints of the [first] three signs are the hypotenuses, which are on the ecliptic, and the Sines of the [corresponding] declinations [of the Sun] are the legs, which are on the respective diurnal circles, [then] the rising arcs [on the celestial equator] are [given] by the corresponding uprights, which are on

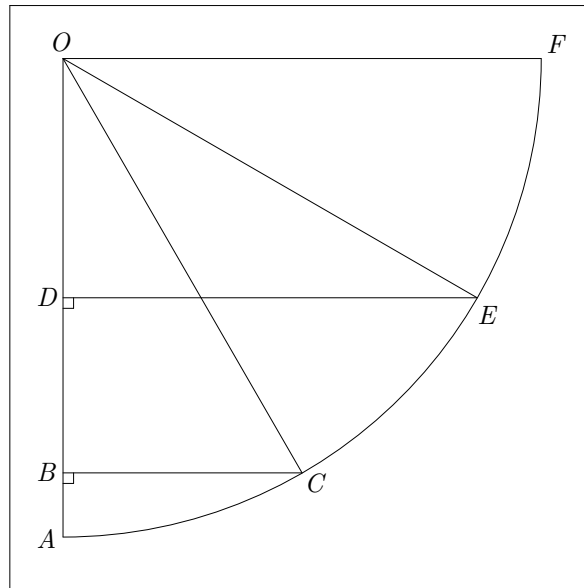


Figure 4.7: The rising arcs

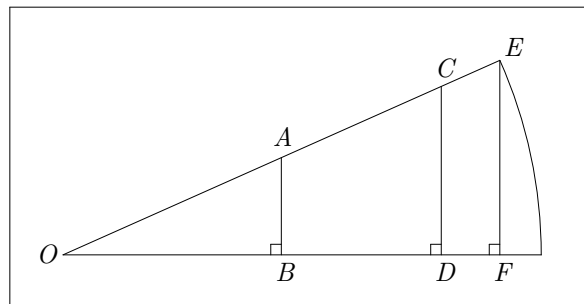


Figure 4.8: The rising arcs

the [corresponding] diurnal circle.

The rising arcs determined here are the segments of the celestial equator corresponding to the three first signs on the ecliptic (measured from the vernal equinox). Since segments of the equator correspond to time, these arcs determine the rising times of the three first signs.

On Figure 4.7, the arc $ACEF$ is part of the ecliptic, the point A marking the vernal equinox. The angles AOC , COE , and EOF are each 30° .

On Figure 4.8, the line $OACE$ is the ecliptic and the line $OBDF$ is the celestial equator. The point O marks the vernal equinox. The points O , A , C , and E are separated by 30° . Therefore, on Figure 4.8 the lengths of OA , OC , and OE correspond, respectively, to the lengths of BC , DE , and OF on Figure 4.7. It follows that on Figure 4.8, the line OA is $\sin(30^\circ)$, the line OC is $\sin(60^\circ)$,

and the line OE is $\text{Sin}(90^\circ)$. Furthermore, as is easily seen, the line AB is $\text{Sin}(\delta_1)$, the line CD is $\text{Sin}(\delta_2)$, and the line EF is $\text{Sin}(\delta_3)$, where δ_1 , δ_2 , and δ_3 are as defined in the preceding.

From all this we see that the line OB on Figure 4.8 is the Sine of the arc on the celestial equator corresponding to the arc OA on the ecliptic, and similarly for OD and OC , and OF and OE . By subtracting appropriately, i.e., subtracting $|OB|$ from $|OD|$ and $|OD|$ from $|OF|$, we can find the Sines of the equatorial rising arcs of the first three signs.

~ TO FIND THE ASCENDANT AT A GIVEN TIME ~

(42^{c-d}–43) The ascendant [can be found as follows]. The *palas* of the given *ghaṭikās* [i.e., the given time in *palas* rather than in *ghaṭikās*] are diminished by the remaining part of the rising time of the sign that the Sun is in [i.e., the time it will take until the Sun enters the next sign] and the *palas* [of the rising times] of the signs that has risen completely. The result of the division of the product of the result and 30 by the rising time of the sign that currently rising is in degrees and so. [This quantity] increased by the signs preceding the currently rising sign beginning from Aries and diminished by the degrees of precession is the [longitude of] the ascendant.

The time [elapsed since sunrise] in *palas* and so on [can be found] from the difference between [the longitude of] the precessional Sun and [the longitude of the] precessional ascendant.

When the ascendant is to be computed at night, the time is [found] from [the longitude of] the Sun increased by six signs.

[When] both [the Sun and the ascendant] are in the same sign, the rising time [of that sign] is multiplied by the degrees [of the angular distance] between them and divided by 30.

I have taken *pūrva* in 43^c in the sense of “signs that has risen completely”. Literally, however, *pūrva* means “preceding”, the sense in which the word is used in 44^a. But taking the meaning to be the “preceding signs” does not make sense here, whereas “signs that has risen completely” fits the context.

The ascendant is the point of the ecliptic that is rising on the local horizon at a given time. The procedure for computing the ascendant is illustrated in Figure 4.9. In the figure, the horizontal line is the local horizon and the oblique line is the ecliptic. The ecliptic is divided into signs by small perpendicular line segments. Suppose that the Sun is at the position P in the sign S_1 , and let A denote the ascendant. Of the signs following S_1 , S_2 and S_3 have risen completely above the horizon, while S_4 is rising.

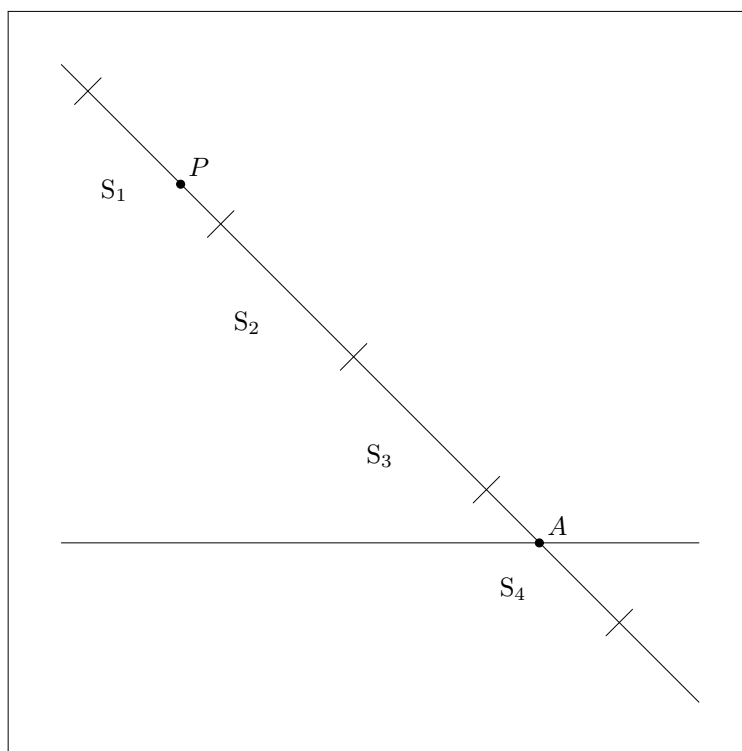


Figure 4.9: Computing the ascendant

Let the rising times of S_1 , S_2 , S_3 , and S_4 be t_1 , t_2 , t_3 , and t_4 , respectively, and let us assume that t *palas* have elapsed since sunrise. At sunrise, the Sun and the ascendant coincided, so between sunrise and the given time, a portion of S_1 , all of S_2 and S_3 , and a portion of S_4 have risen.

If the angular distance between the Sun and the beginning of S_2 is a , it took this segment $\frac{a \times t_1}{30}$ *palas* to rise. It further took $t_2 + t_3$ *palas* for S_2 and S_3 to rise. Subtracting these times from t , we get

$$s = t - \frac{a \times t_1}{30} - t_2 - t_3 \quad (4.52)$$

as the *palas* that it has taken the segment of S_4 from its beginning to the point on the horizon to rise. If this segment spans the angular distance b , then

$$b = \frac{30 \times s}{t_4}. \quad (4.53)$$

We now know the point of S_4 , i.e., A , that is on the horizon. This point is the ascendant. To find its proper longitude, we first have to add all of the preceding signs beginning with Aries, and then convert this tropical longitude to a sidereal one by subtracting the degrees of precession.

~ TREPIDATION EXPLAINED ~

(44) **Aries and so on move eastward away from the celestial equator when the *pravaha* wind is diminished, and westward when [the *pravaha* wind] is increasing. Therefore, the degrees of precession are not the same each year.**

In the following we will continue to use the word “precession” for the motion of the equinoxes against the backdrop of the fixed stars.

In the preceding, we have translated the Sanskrit word *ayana* as precession and the word *sāyana* as “precessional”, which is useful for immediate understanding. However, Jñānarāja’s model does not actually operate with precession of the equinoxes, but rather with trepidation of the equinoxes. Trepidation of the equinoxes is the theory that the vernal equinox moves a certain angular distance to the east, then stops, and move the same distance to the west, then stops and moves the same distance to the east, and so on *ad infinitum*.¹⁹

No details regarding the rate of the motion are given by Jñānarāja. More details are given in the *Sūryasiddhānta*, where it is stated that the trepidation of the equinox extends over an arc of 27° at a rate of $54''$ per year.²⁰

‘

¹⁹For the history of precession and trepidation in early India, see [67].

²⁰*Sūryasiddhānta* 3.9–11. See [71 . 610].

~ TO FIND THE AMOUNT OF PRECESSION ~

(45) The difference between the degrees of [the longitude of] the Sun [determined] from the noon shadow and [the longitude of] the Sun [determined] from a *karaṇa* [work] is the number of degrees of precession.

In this regard, after a year, a difference in minutes of arc [accumulated between the tropical and sidereal longitudes of the Sun] is seen directly.

For the sake of computation of the ascendant, the ascensional difference, and the declination, [this difference must be taken into account].

From the shadow cast by a gnomon at noon, we can find the declination of the Sun, and from the declination its tropical longitude (see 2.1.27–29 and commentary for how to find the declination and longitude). This will differ from the longitude found by carrying out the computations prescribed in a *karaṇa* treatise (a type of astronomical treatise that provides formulae, but not theory; see the Introduction, p. 24), which will give the sidereal longitude. The difference between the two longitudes is the degrees of precession.

As the precessional rate is given as 54'' in the *Sūryasiddhānta*, it is roughly correct that one should see a difference of about a minute of arc after a year.

~ TO FIND THE AMOUNT OF PRECESSION ~

(46) A day [the daylight period of which is] measured by 30 *ghaṭikās* is to be observed. The difference between the degrees of [the longitude of] the Sun on that day and [the longitude of the Sun] on the equinoctial day is the number of degrees of precession. The computation of the declination, the ascendant, and the ascensional difference is to be done from [the solar longitude] corrected by these [degrees of precession].

A day whose daylight period is 30 *ghaṭikās* is an equinoctial day. The idea seems to be that you compute the equinoctial day by an algorithm relying on an outdated value for current precession, and then correct the amount by observing the difference between that and the true equinoctial day with daylight equal to 30 *ghaṭikās*.

~ PRECESSION ACCOUNTING FOR CERTAIN DIFFERENCES ~

(47) The *ghaṭikās* corresponding to the difference between the correct computation of a shadow by the primeval sages and the visible shadow is due to the [precessional] difference.

The method recorded here, which was enunciated by the ancients, is easy, as it is based on proportions and so on, and it does not give errors.

A shadow computation refers to using the shadow cast by a gnomon for determining various astronomical values. This will be taken up in detail in the next section. Now, when one comes across a shadow computation in a work that differs from we see in practice, but is otherwise correct, it is to be understood that the difference is due to precession.

~ CONCLUDING VERSE ~

(48) Thus is the planetary rectification produced from the velocity in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 5

grahagaṇitādhyaṃya section 3

tripraśnādhikāra

Three questions

~ INTRODUCTORY VERSE ~

(1) For the sake of computing the results caused by direction, place, and time, I will now present the section entitled “Three Questions” in the *Sundara* [i.e., the *Siddhāntasundara*], which has a collection of flowers [in the form of] good *vāsanās* [i.e., methods], which is a moving and very wide spherical tree, and which is the greatest.

This chapter deals with three types of questions, namely those relating to direction, place, and time. The wordplay in the verse is not entirely clear. The word *golataroḥ* (literally, sphere-tree) could also refer to the Earth, but it seems most likely that it is this treatise that has flowers in the form of *vāsanās*.

~ DETERMINING THE EAST-WEST AND NORTH-SOUTH LINES ~

(2) The shadow of a gnomon that is straight and positioned on ground that has been made even by means of water [falls along the] south-north [line] at [the time of] the *ghaṭikās* of midday. The east and west directions are produced from the tail and head of [a figure in the shape of] a fish

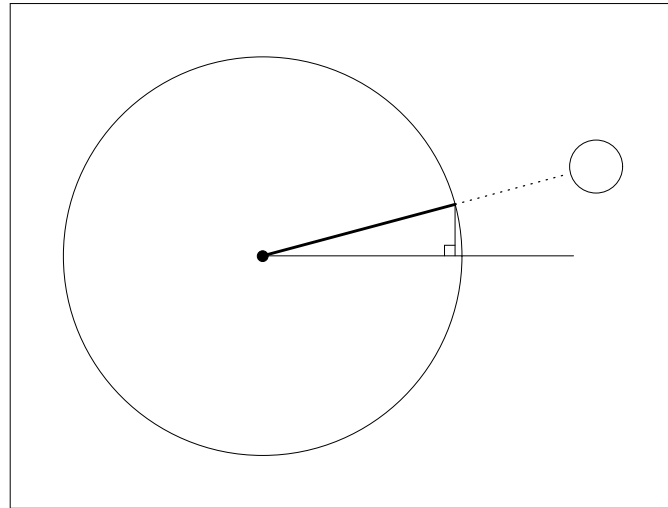


Figure 5.1: Finding the east-west line

produced from it [the north-south line].

This verse is identical to verse 2.1.26, at which place comments are given.

~ AN ALTERNATIVE METHOD FOR DETERMINING THE DIRECTIONS ~

(3) After placing a flexible and straight rod on a peg at the center of a circle [drawn] on even ground on a raised platform, so that it is pointing towards [the rising point of] the Sun, the eastern direction is [found] by means of the degrees in the arc produced by the Sine of the amplitude placed in the opposite direction from its [the rod's] tip on the circumference [of the circle].

Consider Figure 5.1. The larger circle is the circle described in the verse, and the smaller circle is the Sun. The rod, which is the bold line, is oriented towards the position of the rising Sun.

Now, unless it is the equinoctial day, the Sun will not rise exactly due east. The angle between due east and the rising point of the Sun is called the rising amplitude, or simply the amplitude. If the amplitude, which can be found through computation, is known, we can find due east on the circle; on the figure it is the second, non-bold line emanating from the center of the larger circle.

The reason that the amplitude is placed in its opposite direction is that this arc is normally measured from the eastern point, but we are extending it from the rising point of the Sun.

~ ESTABLISHING THE REMAINING DIRECTIONS ~

(4) The western direction extending from the said center is the shadow from a peg at the center. On account of the Sun ... [?]. The western and eastern directions are [determined] in that manner in order. The northern [direction] is given by the polestar. Such is the determination of the cardinal directions.

This verse deals with the establishment of the remaining directions. The procedure is clear from the translation. Note, however, that the meaning of the last part of *pāda* b (*ravivaśena viśaty apaiti*) is unclear and this passage might be corrupt.

~ THE EQUINOCTIAL FIGURE ~

(5) When the precessional Sun is situated at the end of Virgo or at the end of Pisces, the shadow [cast by a gnomon] at noon is the equinoctial shadow.

[In a right-angled triangle,] this [equinoctial shadow] is the leg, the gnomon is the upright, and the hypotenuse is the equinoctial shadow.

This is the first figure among the figures arising from the latitude.

On the equinoctial day, i.e., when the Sun is at one of the equinoctial points (the two intersections between the ecliptic and the celestial equator) and thus on the celestial equator, the shadow cast by the gnomon at noon is called the equinoctial shadow. The corresponding hypotenuse (i.e., the distance between the top of the gnomon and the end of the shadow) is called the equinoctial hypotenuse. It should be noted that the gnomon is always considered to have the height 12.

This is illustrated on Figure 5.2, where g is the gnomon (of height 12), s_0 the equinoctial shadow, and h_0 the corresponding hypotenuse, which is called the equinoctial hypotenuse. Note that the lengths are chosen so as to conform with the situation at the latitude of Pārthapura.

Now, since the Sun is on the celestial equator on the equinoctial day, the angle between the gnomon and the equinoctial hypotenuse is equal to the local terrestrial latitude ϕ . Similarly, the angle between the equinoctial shadow and the equinoctial hypotenuse is the local co-latitude $\bar{\phi}$ (the co-latitude is defined as 90° diminished by the latitude, i.e., $\bar{\phi} = 90^\circ - \phi$).

The triangle given here is the first in a series of similar triangles that will be presented in the following.

~ SIMILAR RIGHT-ANGLED TRIANGLES FROM AN ANALEMMA ~

(6–11) The vertical line from the equinoctial point [at noon] to the Earth is

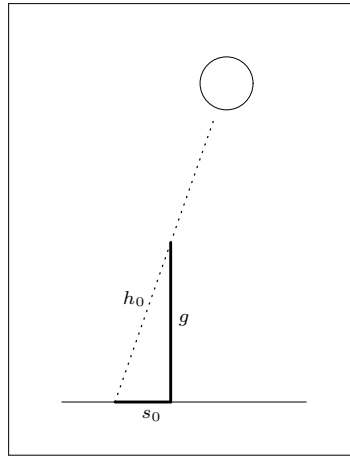


Figure 5.2: Shadow cast by a gnomon at noon on an equinoctial day

the Sine of the local latitude, which is the leg [of a right-angled triangle]; the radius, which is between the center of the Earth and the equinoctial point, is the hypotenuse; and Sine of the co-latitude is said to be the upright. This [upright] is situated at the tip of the Sine of the local latitude from the center of the Earth.

[In a right-angled triangle,] the earth-Sine, which is known from the previous, is the leg. The [corresponding] upright is the Sine of the declination [of the Sun], and the hypotenuse is the Sine of the amplitude.

[This right-angled triangle can be divided into two right-angled triangles as follows.] One leg is the earth-Sine, another the Sine of the declination [of the Sun]. The base is the Sine of the amplitude, and the upright is the Sine of the six-o'clock altitude.

[In the first of these triangles,] the first segment of the base is the part beginning at the tip of the Sine of the amplitude; it is the upright. The [corresponding] hypotenuse is the Sine of the declination, and the leg is the Sine of the six-o'clock altitude.

[In the second triangle,] the other segment of the base is the leg. The [corresponding] upright is the Sine of the six-o'clock altitude, and the hypotenuse in this right-angled triangle is the earth-Sine.

The perpendicular from the [position of] the Sun when it is on the prime vertical [i.e., the Sine of the altitude of the Sun when it is on the

apparent motion around the Earth (following the apparent motion of the fixed stars); it is the line AB on Figure 5.3. The prime vertical is the great circle that is perpendicular to the horizon and passes through the east and west points; it is the line OZ on Figure 5.3.

The six-o'clock altitude is the altitude of the point of intersection between the six-o'clock circle and the diurnal circle.

The earth-Sine was introduced in the previous chapter (see 2.2.34). It is the arc of the diurnal circle between the horizon and the six-o'clock circle, i.e., the angular distance traveled by the Sun between its rising and its reaching the six-o'clock circle. Of course, this is the same angular distance as between the Sun reaching the six-o'clock circle in the evening and its setting. Taken either way, it is the line AG on Figure 5.3.

The amplitude is the arc on the horizon between the east point (O on Figure 5.3) and the intersection between the horizon and the six-o'clock circle (the point A on Figure 5.3). Note that we could similarly have defined the amplitude with respect to the west point. With our definition, it is the angular distance between the east point (O) and the point where the Sun rises or sets. It is the line OA on Figure 5.3.

Note that the celestial radius used in the above is taken to be equal to the trigonometric radius for simplicity of computation. As such, the length of OC in Figure 5.3 is $R = 3438$. We can now use Sines to express other lengths. For example, the length of the line OG is thus the Sine of the declination of the Sun, i.e., $\text{Sin}(\delta)$.

Figure 5.4 shows triangle OAH in Figure 5.3 with further divisions according to the verses. The angle ϕ is the local latitude, and the angle $\bar{\phi}$ is the local co-latitude.

The eight triangles (given in the order: leg, upright, and hypotenuse) listed by Jñānarāja are as follows:

1. the equinoctial shadow, the gnomon, and the equinoctial hypotenuse, which is shown in Figure 5.2;
2. triangle OCD in Figure 5.3, containing the Sine of the latitude OD , the Sine of the co-latitude CD , and the radius OC ;
3. triangle OAG in Figure 5.4, containing the earth-Sine AG , the Sine of the Sun's declination OG , and the Sine of the amplitude OA ;
4. triangle OFG in Figure 5.4, containing the Sine of the six-o'clock altitude GF , the first segment of the Sine of the amplitude OF , and the Sine of the declination OG ;
5. triangle AFG in Figure 5.4, containing the second segment of the Sine of the amplitude AF , the Sine of the six-o'clock altitude FG , and the earth-Sine AG ;
6. triangle OAH in Figure 5.4, containing, the Sine of the amplitude OA , the Sine of the prime-vertical altitude OH , and the prime-vertical hypotenuse AH ;

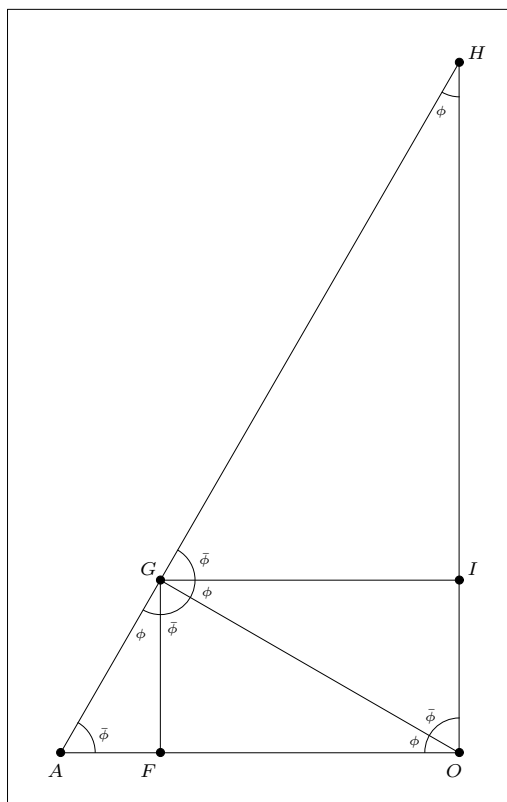


Figure 5.4: Triangle OAH from Figure 5.3

7. triangle GHI in Figure 5.4, containing the first segment of the Sine of the amplitude GI , the Sine of the prime-vertical altitude diminished by the Sine of the six-o'clock altitude HI , and the prime-vertical hypotenuse diminished by the earth-Sine GH ; and
8. triangle OGH in Figure 5.4, containing the Sine of the declination OG , the prime-vertical hypotenuse diminished by the earth-Sine GH , and the Sine of the prime-vertical altitude OH .

That all of these triangles are similar is easy to see.

~ SIMILAR TRIANGLES AND PROPORTIONS ~

(12^{a-b}) **By means of the measures of the leg, hypotenuse, and upright in any one among these [right-angled triangles], a computation of the leg and so on in another right-angled triangle [among the ones given] can be carried out by means of a proportion.**

Since all the right-angled triangles given are similar, we can use a proportion to determine unknown sides. Jñānarāja will give some examples of this below in verses 13–16.

~ RELATIONSHIP OF THE SIDES IN A RIGHT-ANGLED TRIANGLE ~

(12^{c-d}) **The hypotenuse [in one of the right-angled triangles] is [equal to] the square root of the sum of the square of the leg and the square of the upright. The upright is [equal to] the square root of the difference of the square of that [hypotenuse] and the square of the leg.**

If l , u , and h are the leg, the upright, and the hypotenuse, respectively, in a right-angled triangle,

$$h = \sqrt{l^2 + u^2}, \quad (5.1)$$

and

$$u = \sqrt{h^2 - l^2}. \quad (5.2)$$

Both results follow directly from the Pythagorean theorem.

~ EXAMPLE OF THE USE OF A PROPORTION ~

(13) **If the upright and the leg are, respectively, the gnomon and the equinoctial shadow when the hypotenuse is the equinoctial shadow, then what are they when it [the hypotenuse] is measured by the radius? [In**

this case,] the upright and the leg are the Sine of the co-latitude and the Sine of the latitude, respectively.

This verse provides an example of how to use a proportion based on two of the given triangles, in this case the first and second triangles in the list of similar triangles on p. 179.

Now, if l and u are the leg and the upright of the second triangle, we get from two proportions that

$$\frac{l}{R} = \frac{s_0}{h_0} \quad (5.3)$$

and

$$\frac{u}{R} = \frac{g}{h_0}, \quad (5.4)$$

from which it is seen that $l = \text{Sin}(\phi)$ and $u = \text{Sin}(\bar{\phi})$.

~ ANOTHER EXAMPLE OF A PROPORTION ~

(14) [If] the leg [of a right-angled triangle] is the shadow when the shadow-hypotenuse is the one at noon, then what is it [the leg] when the hypotenuse is the radius? The Sine of the degrees of the zenith distance [of the Sun] is attained as the result. From this [Sine] the degrees of the latitude are to be computed as was explained.

Consider Figure 3.2 on p. 107 in the commentary on verses 2.1.27–29^a. On an arbitrary day, the shadow triangle (gnomon, shadow, and shadow-hypotenuse) is similar to the right-angled triangle with hypotenuse OS and one leg along the line OZ in Figure 3.2.

~ FURTHER EXAMPLES OF PROPORTIONS ~

(15–16) The equinoctial shadow is [separately] multiplied by the Sine of the six-o'clock altitude, the Sine of the amplitude, the first segment of the Sine of the amplitude, and the second segment of the Sine of the amplitude and [each result is] divided [separately] by the equinoctial shadow. [The results] are the Sine of the declination of the Sun, the prime-vertical hypotenuse, the upper segment of that [prime-vertical hypotenuse], and the earth-Sine.

The Sine of the six-o'clock altitude, the Sine of the amplitude, the first segment of the Sine of the amplitude, and the second segment of the Sine of the amplitude are [separately] multiplied by 12 [i.e., the height of the gnomon] and divided by the equinoctial shadow. [The results] are, respectively, the first segment of the Sine of the amplitude, the Sine of

the prime-vertical altitude, the upper segment of that [Sine of the prime-vertical altitude], and Sine of the six-o'clock altitude.

The first four proportions given are derived from the similarity of the first triangle with the fourth, the sixth, the seventh, and the fifth triangles, respectively, from the list of similar triangles on p. 179. The next four proportions are derived from the similarity of the first triangle with the same four triangles in the same order.

~ PROBLEMS RELATING TO LOCATION ~

Now [some] questions concerning location.

~ A PROBLEM CONCERNING LOCATION ~

(17) [Narrative translation:] Tell [me] the length of the journey of the swift man, who, upon learning that his friend had gained kingship and was sitting on the lion's seat [i.e., the throne], deprived of luster went north [to a place where] he had the luster of a former king.

[Technical translation:] Tell [me] the length of the journey of the swift man, who, upon learning that the sun had attained lordship sitting in the lion's seat [i.e., was in Leo], cast no shadow and who went north [until] he had a shadow of [length] 16 [falling] towards the east.

This is the first of the problems posed in this chapter where the poetic technique of double entendre (*śleṣa*) is employed. As was stated in the introduction, it is necessary to give two separate translations for each of these verses, one narrative and one technical.

As can be seen, the narrative translation sets the scene. A king has been ousted by his friend, who now occupies the throne, and flees to another region, where he is given recognition as a former king. A question is posed, but the narrative does not give the information needed to answer it. For this we need to reread the verse, leading to the technical translation.

The problem can be solved as follows. We have two places: P_1 , the point of departure, and P_2 , the point of arrival. As the journey is due north and the circumference of the earth is 5059 *yojanas* according to the *Siddhāntasundara* (see 1.1.74), we only need to know the latitudes of P_1 and P_2 , ϕ_{P_1} and ϕ_{P_2} , to determine the distance between them.

At P_1 , there is no shadow, so the sun is in the zenith, which means that $\phi_{P_1} = \delta$, where δ is the declination of the Sun. Now, the statement that the Sun is in the Lion's seat means that the Sun is in Leo. In fact, Jñānarāja intends for it to be at the midpoint of Leo (see solution to this

verse below), in other words, we know that λ^* , the sun's tropical longitude, is $\lambda^* = 4^s 15^\circ = 135^\circ$ (the notation 1^s means 1 sign, i.e., 30°). By using Jñānarāja's small Sine table and the formula $\text{Sin}^\ell(\delta) = \text{Sin}^\ell(\varepsilon) \times \text{Sin}^\ell(\lambda)/R$, where $\varepsilon = 24^\circ$ is the obliquity of the ecliptic, we get $\text{Sin}^\ell(\delta) = 45;2$, and then $\delta = 16^\circ 31'$ (see Equation 4.36 on p. 160). Hence $\phi_{P_1} = 16^\circ 31'$.

At P_2 , the shadow has length 16 and falls due east, which means that the Sun is on the prime vertical. We can find α , the altitude of the Sun, by the proportion $\frac{\alpha}{R} = \frac{g}{\sqrt{g^2 + s^2}}$, where g is the length of the gnomon, i.e. 12, and s is the length of the shadow, i.e. 16, which gives $a = 96$. Since the Sun is on the prime vertical, $\frac{\text{Sin}(\delta)}{\alpha} = \frac{\text{Sin}(\phi_{P_2})}{R}$, which gives us that $\text{Sin}(\phi_{P_2}) = 75\frac{3}{60}$ and $\phi_{P_2} = 28^\circ 19'$.

Now, the degrees that the man traveled north are $\phi_{P_2} - \phi_{P_1} = 28^\circ 19' - 16^\circ 31' = 11^\circ 48'$, which by the next verse corresponds to $14 \times 11;48$ *yojanas*, or $165;12$ *yojanas*. This is approximately 1300 kilometers, roughly the distance between Hyderabad and Delhi.

The term *siṃhāsana* (lion's seat) is used in the verse is an astrological term found in the *Bṛhat-pārāśarāhorāśāstra*.¹ However, it is not used in this sense here.

~ TO COMPUTE THE DISTANCE BETWEEN TWO LOCATIONS OF THE SAME LATITUDE ~

(18) **[Here is] the rule: The difference of the latitudes at two locations is multiplied by 14. Thus the *yojanas* of the journey [are found].**

As the circumference of the Earth is 5059 *yojanas* (see 1.1.74) there are

$$\frac{5059}{360} = 14\frac{19}{360} \approx 14 \quad (5.5)$$

yojanas per degree on any great circle through the poles. Therefore, if a person is traveling straight north or straight south, the length of his journey in *yojanas* can be found by multiplying the difference of the latitude of the place from which he set out and the latitude of his destination by 14. For this formula, see also 1.1.25.

~ SOLUTION TO VERSE 17 ~

In this case, the Sun is at the midpoint of Leo [i.e., its tropical longitude is] $4^s 15^\circ$. The first shadow [has length] 0, the second [has the length] 16 [falling towards] east. In this case, by the method given in verse 22, having computed the degrees of the latitude from the equinoctial shadow, the *yojanas* found are 167.

Most manuscripts give 157 *yojanas* rather than 167. However, we got $165;12$ *yojanas* above. Note that Jñānarāja's solution is really only a sketch.

¹*Bṛhatpārāśarāhorāśāstra* 6.45–47 (see [84, 1.87]). I am thankful to Martin Gansten for calling my attention to this astrological usage of the term *siṃhāsana*.

~ A PROBLEM CONCERNING LOCATION ~

(19) [Narrative translation:] When a good goose perished in the mouth of a crocodile, the best among sages left [lake] Mānasa. [While on his way,] he saw a light in the northeastern direction resembling [the deity] Śiva. Tell me the equinoctial shadow at that place!

[Technical translation:] When the Sun, which was at the beginning of Capricorn, was setting, the best among sages left [lake] Mānasa. [While on his way,] he saw that the shadow [of a gnomon] was [of length] 11 in the northeastern direction. Tell me the equinoctial shadow at that place!

Both the narrative and technical meanings of the verse are clear, but the solution to the problem, as per the following verses is not clear.

~ TO COMPUTE THE GIVEN SHADOW AND THE GIVEN DIRECTION ~

(20–21) The difference between the square of the Sine of the declination [of the Sun] and the square of the Sine of the altitude [of the Sun] is multiplied by 2. This is the divisor [*hāra*]. It is multiplied by the sixth part of the Sine of the altitude [of the Sun]. This is the mean leg [*bāhu*]. Whatever is the difference between the square of the Sine of the declination [of the Sun] and [this] leg multiplied by 2 times the divisor, the square root of the difference or the sum of the square of that and the square of the mean [leg] is decreased or increased by the mean [leg], depending on whether [the Sine of] the altitude [of the Sun] is greater or smaller than [the Sine of] the declination. In this case, whatever is the result [from the division of this quantity] by the divisor, that is the equinoctial shadow. [This] multiplied by the direction Sine is the [given?] shadow. The [mean?] leg divided by the [corresponding shadow-]hypotenuse [?] is the given direction.

When the direction Sine [is found] by means of the radius R , what [is found] from the [given?] shadow? When it is understood that the leg is not subtracted from that which is to be subtracted [?], then, by means of an inverse [procedure] that which is to be subtracted is entire by means of one's own intelligence.

The direction Sine is the Sine of the degrees separating the current altitude-circle of the Sun from the prime vertical.

The procedure in these two verses is not clear.

~ DEMONSTRATION VERSE FOR PREVIOUS TWO VERSES ~

The demonstration verse for verses 20–21 [is given now].

~ DEMONSTRATION VERSE FOR VERSES 20–21 ~

(22) One should compute the base of [the Sine of] the altitude by means of the unknown equinoctial shadow. [The sine of] the amplitude [is found] from the correction of the leg by that [base of the Sine of the altitude]. The square of the *palabhā* [equinoctial shadow?] is increased by the square of 12 [i.e., 144]. [This is] the square of the equinoctial hypotenuse. The square of [the Sine of] the amplitude is divided by the square of 12 multiplied by the square of the Sine of the declination [of the Sun]. The square of the previous [eastern?] [Sine of] the amplitude is equal to that. In this case, the equinoctial shadow [is found] from an application of *bījas* from the same *karāṇa* [treatise].

The procedure outlined here is unclear.

~ SOLUTION TO VERSE 19 ~

[The tropical longitude of] the Sun is $9^s0^o0'0''$. By means of the method [for computing a sine using the table] of small Sines, the Sine of the declination [of the Sun] corresponding to that [tropical longitude] is 64;20, [the Sine of] the altitude is 117;48, the direction Sine is 112;0. The equinoctial shadow found [from this] is 1;7, and the [corresponding] degrees of terrestrial latitude are 5;7.

Since the tropical longitude of the Sun is $\lambda^* = 9^s$, $\text{Sin}^\ell(\lambda^*) = R$ (note that since we are operating with small Sines, $R = 160$). By the formula given in 2.32^{c-d},

$$\text{Sin}^\ell(\delta) = \frac{\text{Sin}^\ell(\lambda^*) \times \text{Sin}^\ell(\varepsilon)}{R} = \text{Sin}^\ell(\varepsilon) = \text{Sin}^\ell(24^\circ). \quad (5.6)$$

Using the formula given in 2.2.13–14, we get

$$\text{Sin}^\ell(24^\circ) = \frac{6}{9} \times 23 + 24 + 25 = 64;20. \quad (5.7)$$

The rest of the solution is not clear.

~ A PROBLEM ~

(23) [Preliminary narrative translation:] The friend, having the splendor of the previous [deity] Indra, causes pain to the hands of a virgin, his hands being harsh hands; [he is] clad in good cloth and jewels, located amongst the star-maidens [?], accompanied by his teachers and knowledgeable poets, and being the lord of chariots, horses, and men [probably referring to an army regiment]. O friend, tell me by how many *yojanas* the city where [this man is] is from [the city of] Dhārā in the direction of south-east.

[Preliminary technical translation:] The Sun, the sharp-rayed one, which is causing pain to Virgo with its rays, throwing a shadow equal [in length] to 14 [falling] towards the east. [Rest of the verse unclear.]

Neither the narrative nor the technical translation is clear, especially the technical translation. The approach to a solution, outlined in verses 24–30, is also not clear.

~ [NOT CLEAR] ~

(24) The direction Sine is multiplied by 12 and divided by the radius and by the local equinoctial shadow. [That is] the unknown. The product of [the Sine of] the amplitude and 12 is divided by the equinoctial shadow. That is the known. Then [that] is mean [?]. There is pair of the unknown and the known which is a product [?]. Whatever is the square root of the square of the unknown increased by 1, [that] is the divisor, it is said. The mean divided by the divisor and [then] halved is the [desired] result.

The procedure in the verse is not clear.

~ TO FIND THE YOJANAS BETWEEN TWO POINTS ON A MERIDIAN ~

(25) The difference between the square produced from the known and the square produced from the half-diameter [?] is to be added to the result [?] that has been squared. When the known is less than the half-diameter or greater than it the difference of the two [quantities] is to be computed. The square root of that divided by the divisor increased or diminished by

the result is the before-mentioned Sine of the zenith distance [of the Sun]. When multiplied by the degrees in its arc its measure is 14. These are the *yojanas* in the distance [between two locations on the same meridian].

The procedure is not clear.

~ TO FIND THE SINE OF THE ZENITH DISTANCE [?] ~

(26) The equinoctial hypotenuse at a city [whose latitude is] known is multiplied by the Sine of the latitude of a city [whose latitude] is not known and divided by 12. This is [the Sine of] the amplitude. It is said that by means of [the Sine of] the amplitude of the Sun the Sine of the *yojanas* in the distance [between the two locations can be found]. If it is the given direction, it is [the Sine of] the zenith distance [?].

The procedure is not clear.

~ SOLUTION FOR VERSE 23 ~

In this case, [the tropical longitude of] the Sun is $5^s10^o0'0''$. The shadow is 14 and the [shadow] hypotenuse is 18;26. By means of [the method of] small Sines, [the Sine of] the altitude is 104 and the Sine of the declination is 22;0. The equinoctial shadow is 237 and the equinoctial hypotenuse is 1217. [The Sine of] the zenith distance, attained as was explained, is 118. The *yojanas* are 667.

It appears that the *yojanas* between the two cities in verse 23 are the number of degrees in the zenith distance multiplied by 14. Let this zenith distance be z . If $\text{Sin}^\ell(z) = 118$, then $14 \times z \approx 665$. Verse 23 is still not entirely clear.

~ TO FIND THE SINE OF THE AMPLITUDE [?] ~

(27) Supposing that the sphere of the Earth is a perfect sphere, one's own city is at an intersection with the sky [?]. Therefore, it is to be imagined that the given city is on a circle through the zenith and the Sun [?] located at the degrees of the sky [?]. In this case, [the Sine of] the zenith distance is the Cosine of that by means of the degrees between the two cities. [The Sine of] the altitude is the leg [of a right-angled triangle].

The degrees between that and the prime vertical is the base of [the Sine of] the altitude; it is [the Sine of] the amplitude.

The procedure is not clear.

~ TO FIND THE BASE OF THE SINE OF THE AMPLITUDE ~

(28) [If] the direction Sine [is found] by means of the Sine of the degrees of the distance [between two locations?] being [equal to] the radius R , what leg [of a triangle is found] by means of the Sine of the degrees of the distance being [equal to] the unknown? In this case is [the Sine of] the amplitude diminished or increased by the leg measured by the result. This is the base of [the Sine of] the altitude in the northern and southern hemispheres, respectively.

The procedure is not clear.

~ [NOT CLEAR] ~

(29) If the upright measured by [the longitude of] the Sun [is found] from one's own equinoctial shadow, then what Sine of the upright is the result in case of the leg measured by the base of [the Sine of] the altitude?

The square of 3 [or of the radius R ?] is diminished by the square of the Sine of the leg which is not known is the square of the Cosine of the degrees of the distance. Eastern [part] of the sky [?].

The procedure described is not clear.

~ USE OF $\bar{b}\bar{i}j\bar{a}$ CORRECTIONS ~

(30) It is said that it is the same by means of a square [?]. For the sake of the Sine of the arc of the degrees of the distance, a $\bar{b}\bar{i}j\bar{a}$ correction is to be applied for the sake of making them equal.

The procedure is not clear.

For $\bar{b}\bar{i}j\bar{a}$ corrections, see the note in the commentary on 2.83–84.

~ A PROBLEM ~

(31) [Preliminary narrative translation:] When the good friend [i.e., Lakṣmaṇa], resting on the lap-part of Rāma, perished, Hanumat went from Laṅkā towards the NE direction with a desire for the cure for the arrow-wound. He stood gazing at the brightness of the straw similar to rocks that reached up to the peak of Mt. Śrīkaṇṭha. O learned one, tell the journey if you are the sun illuminating the digits of the moon.

[Preliminary technical translation:] When the sun, situated in the 9th degree of Virgo, set, Hanumat went from Laṅkā towards the NE direction with a desire for the cure for the arrow-wound. He stood gazing at the noon shadow equal [in length] to 7 and facing the cardinal point of Siva's direction [NE]. O learned one, tell the journey if you are the sun illuminating the digits of the moon.

The verse is not entirely clear.

~ A PROBLEM ~

(32) [Preliminary narrative translation:] By means of which time do I see a friend being seated on the lion's seat [i.e., the throne], obeying the command of [the deity] Indra by means of enjoyment on the same circle [?], and bowing down to the foot of [the deity] Viṣṇu in a known city?

[Preliminary technical translation:] By what time do I see the Sun being in Leo, filling [?] the eastern direction by means of motion on the prime vertical, and bowing down to the foot of Viṣṇu [a star?] in a known city.

Neither the narrative nor the technical parts of the verse are clear.

~ TO COMPUTE THE GIVEN DIRECTION ~

(33) [The Sine of] the zenith distance [of the Sun] is to be computed, as explained, by means of [the Sine of] the amplitude of the Sun. By means of that [are found] the *ghaṭikās* in the given direction-shadow [?]. Entering the given direction in these *ghaṭikās*, the shadow of the Sun [can be found], and from that the given direction is to be computed.

~ A PROBLEM ~

(34) Tell me the shadow of the Sun extending its part in the direction of north-east for one gone to Viṣṇu [?] in the vicinity of Ātmatīrtha on the bank of the [river] Godāvarī whose equinoctial shadow is 4;20. Tell [me] also, O friend, the equinoctial shadow measured by 5;40 in the direction of north-east, by how many *yojanas* by one bringing [?]? I desire Vārāṇasī!

Neither the narrative part or the technical part of this verse is fully clear.

~ SOLUTION FOR VERSE 34 ~

Here [the longitude of] the Sun is 4;15. The Sine of the declination [of the Sun] is 47;49. The direction Sine is 112. The unknown is 1;56. The known is 132;25. The mean [leg?] is 510;40. The divisor is 2;7. The result is 120;40. The square root [of that] is 150. [The Sine of] the zenith distance is 30. The shadow is 1;8.

~ AN ALTERNATIVE SOLUTION FOR VERSE 34 ~

Now, by means of another method the computation of the Sine of the *yojanas* in the distance [is computed] in this manner. The equinoctial shadow in Vārāṇasī is 5;40. The [shadow] hypotenuse is 1317. The Sine of the latitude is 68;12. The unknown is 1;56. [The Sine of] the amplitude is 72;27. The known is 200;38. The divisor is 2;8. The mean [leg?] is 775;14. The result is 181;30. The square root [of that] is 138;0. The Sine of the zenith distance [of the Sun] is 23;30. Therefore, the *yojanas* in the distance are 126.

~ TO FIND THE DIRECTION SINE ~

(35) The Cosine of the degrees of the distance is divided by 12 and multiplied by the equinoctial shadow. From a correction by the mentioned [Sine of] the amplitude, and multiplied by the radius R and divided by the Sine of the distance, we get the direction Sine.

Let s_0 be the equinoctial shadow. Let z be the Sun's zenith distance and α its altitude. Then $\text{Cos}(z) = \text{Sin}(\alpha)$. When $\text{Sin}(\alpha)$ is multiplied by $\frac{s_0}{12}$, we get the base of the Sine of the altitude. Adding or subtracting the Sine of the amplitude, we finally get the direction Sine, i.e., the Sine of the degrees between the Sun's current altitude-circle and the prime vertical.

~ A PROBLEM ~

(36) **At night, when the Sun and the Moon were in Capricorn, a thief stole the best of the king's horses and quickly went 580 *yojanas*, and computed a shadow to the east equal to 12, revolving in its own direction.**

Neither the narrative nor the technical meanings are fully clear.

~ SOLUTION FOR VERSE 36 ~

[The tropical longitude of] the Sun is 9;0,0,0. The Sine of the declination of the Sun is 65. The shadow is 12. The [shadow] hypotenuse is 17. The direction Sine is found by means of the given method [and is] 112.

~ THE ANTĀ AND THE HṚTI ~

(37) **According to the hemisphere, the radius is increased or decreased by the Sine of the ascensional difference and likewise the radius of the diurnal circle is increased or decreased by the earth-Sine. These are the *antā* and the *hṛti*, respectively.**

The verse defines the *antā* and the *hṛti*, which will be used in the following.

Consider Figure 5.3 on p. 178. Let r be the radius of the diurnal circle. Then r is the length of the line GB . If we increase this length of the earth-Sine, i.e., the length of AG , we get the *hṛti*, which is thus the length of the line AB . In the case where BG extends beneath the horizon (i.e., if it is on the other side of the point O), we need to subtract the earth-Sine rather than add it.

Consider again Figure 5.3. The arc AG is part of the diurnal circle and thus corresponds to a time (the time it takes for the Sun to traverse this arc). However, is measured on the celestial equator, not the diurnal circle, and there is thus a segment of the celestial equator, extending beneath OC that corresponds to the arc AG (this segment, of course, is the ascensional difference). If the radius of the celestial equator, i.e., R , is increased by a length corresponding to that segment, we get the *antā*. As before, there are also situations where the segment needs to be subtracted.

~ THE ZENITH DISTANCE AND ALTITUDE OF THE SUN ~

(38) According to the hemisphere, at midday, the leg and the upright corresponding to the difference or the sum of the degrees of the local latitude and the declination [of the Sun] are to be computed; they are the Sine of the zenith distance [of the Sun] and [the Sine of] the altitude [of the Sun], respectively.

In this case, the Sine of the zenith distance [of the Sun] multiplied by 12 and divided by [the Sine of] the altitude [of the Sun] is the shadow [of the gnomon].

The shadow-hypotenuse is the square root of the sum of the square of that and the square of 12.

Let ϕ be the local latitude, δ the declination of the Sun, z the zenith distance of the Sun, and α the altitude of the Sun. The first result amounts to

$$\text{Sin}(z) = \text{Sin}(\phi \pm \delta) \quad (5.8)$$

and

$$\text{Sin}(\alpha) = \text{Cos}(\phi - \delta). \quad (5.9)$$

See 2.1.27–29^a and the commentary thereon.

The second result follows easily from similar triangles, and the third from the Pythagorean theorem.

~ CURRENT ANTĀ AND CURRENT HṚTI ~

(39) The *antya* at midday diminished by Versed Sine of the *asus* of the hour-angle on the diurnal circle is said to be the current *antya*.

That multiplied by the radius of the diurnal circle and divided by the radius is the current *hṛti*.

[That] multiplied by 12 and divided by equinoctial hypotenuse is the current [Sine of the] altitude [of the Sun].

An *asu* (literally, breath) is a unit of time corresponding the rising of 1 minute of arc of the celestial equator. All of the results given in the verse are easily verified via similar triangles.

~ THE CURRENT ALTITUDE AND THE HṚTI ~

(40) [The first two *pādas* unclear.]

The current [Sine of the] altitude is attained as the the radius times 12 divided by the hypotenuse.

That [current Sine of the altitude] multiplied by the equinoctial hypotenuse and divided by 12 is the *hṛti*.

The first result follows from the fact that in any shadow-triangle (i.e., one formed by a gnomon, its shadow, and the shadow-hypotenuse), the Sine of the current altitude of the Sun is to R as 12 (the height of the gnomon) is to the shadow-hypotenuse.

~ CURRENT ANTĀ ~

(41) The current *hṛti* multiplied by the radius and divided by the radius of the diurnal circle is the [current] *antyā*.

The reverse [?] arc of the remainder of the *antyā* with half [the duration of] the day subtracted is the *asus* in the hour-angle. Half the day diminished by that is the *ghaṭikās* of the elevation.

The first formula is correct. Since the current *antyā* is the arc on the celestial equator corresponding to the diurnal-circle arc represented by the current *hṛti*, the ratio $\frac{R}{r}$ can be used to find the latter from the former. Similarly, since the arc of the current *antyā* represents time since sunrise, that arc can be subtracted from the entire length of the day, giving us the “remainder of the *antyā*”. If we take away half the length of the day from this remainder, we get the time since sunrise again, or the time corresponding to the current elevation of the Sun.

~ SOME DEFINITIONS ~

(42) At the intersection of the meridian and the diurnal circle it is noon. The *antyā* and the *hṛti* situated from the rising-string are said to be the two hypotenuses. The difference between the rising string of *Laṅkā* and the local rising string is the earth-Sine or the ascensional difference.

When the radius of the diurnal circle and the radius are diminished or increased by that according to the hemisphere, [we get] the *hṛti* and the *antyā*, [respectively].

It is clear that when the Sun, moving along the diurnal circle, reaches the meridian, it is noon.

~ SOME DERIVATIONS ~

(43) The versed Sine of the hour-angles of the mean [leg?] and the given *antyā* is the distance [?]. The given *antyā* is diminished by that; it is the *hṛti* made on the circle known as the earth-Sine[-circle]. If the upright [in a triangle] is by means of the equinoctial shadow, then what it is measured by 12? It is [the Sine of] the altitude in the case of the *hṛti* [?]. When the radius R by means of that is the hypotenuse, when [the Sine of] the altitude is measured by 12, what is the given hypotenuse?

The procedure is not clear.

~ SOME DERIVATIONS ~

(44) When the oblique [?] arc of the one greater than the radius R is to be determined, subtract the radius R , [and you get] the remainder-arc, respectively [?]. Increased by 5400 it is the oblique [?] arc by means of adding the arc [corresponding to] the Sine [?]

The procedure is not clear.

~ A CRITICISM OF BHĀSKARA II ~

(45) Whatever is said in the *Siddhāntaśiromaṇi*, that the six-o'clock altitude multiplied by the noon *antyā* and divided by the Sine of the ascensional difference is [the Sine of] the noon altitude, or otherwise that [the Sine of the noon altitude] is the *hṛti* multiplied by the upright produced by the equinoctial figure and divided by the corresponding hypotenuse, all that breaks down on the equinoctial day and is therefore not presented by me.

Jñānarāja here critiques a verse from the *Siddhāntaśiromaṇi*.² The problem with the formula cited from the *Siddhāntaśiromaṇi* is that on the equinoctial day both the six-o'clock altitude and the ascensional difference are 0, yielding the mathematically meaningless expression

$$\frac{0}{0}. \tag{5.10}$$

Since the formula works for any other day, Jñānarāja's complete rejection is interesting. His rejection based on division by 0 in one instance is further interesting in that his predecessors (Brahmagupta, for example) attempted to define such a division. More information about this might be found

²*Siddhāntaśiromaṇi*, *grahagaṇitādhyāya*, *tripraśnādhikāra*, 36.

in the *bījagaṇitādhyaṃya*.

~ CONCLUDING VERSE ~

(46) [Thus ends the section on] the three questions for the sake of computation of time, direction, and place in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 6

grahagaṇitādhyāya section 4

parvasambhūtyadhikāra

Possibility of eclipses

~ DETERMINING THE LUNAR NODE [?] ~

(1-2) The weekday, located from the star of the Sun [?], is diminished by 39, 30, 24, 21, 20, 20, 20, 20, 22, 26, 33, 45, 73, 200 *palas* due to the [cosmic] wind, and increased by 400, 100, 60, 49, 44, 44, 44, 52, 72, 132, 0, 114 *palas*, [respectively]. At a syzygy, [the longitude of] the Sun is increased by the signs and so on of what has been traversed. Its velocity is found from the day [perhaps *tithi*?]. The result consists of the minutes of arc of the [lunar] node. 1, 2, 3, 4, 5, 5, 5, 6, and 7 [?]. It [the result] is converted to degrees in the direction of the degrees of the arc of the center of the Sun [?] and [applied] to the node. Otherwise, it is corrected.

These two verses are not clear. While tables in the margins of R₁ and R₂, and an annotation in the margin of V₂ identify the numbers as going with the *nakṣatras*, it is not at all clear what these numbers are, or what purpose applying them to the weekday has with respect to eclipse possibilities. In addition, there are 27 *nakṣatras*, but only 26 numbers given.

~ TO FIND THE LONGITUDE OF THE LUNAR NODE ~

(3^{a-b}) [When] 19;21,33,33 [degrees] is multiplied by the current *śaka* year diminished by 1425, and [the result] is increased by 4;3,32, [we get the longitude of] the lunar node in degrees and so on [at the beginning of the current *śaka* year].

The verse gives a method for computing the longitude of the lunar node, providing a multiplier (19°21'33"33''') and an addend (4°3'32''). See the commentary on 2.1.57–64. This method for determining the longitude of the lunar node is, however, peculiar. Firstly, it gives the longitude for the beginning of *śaka* 1425, whereas the epoch given earlier (see 2.1.57–64) falls about half a year later. Secondly, the multiplier and the addend that are given are not consistent with those given previously. The multiplier for the lunar node given earlier is 19°21'11"24''', not 19°21'33"33'''. Furthermore, using Jñānarāja's parameters, the addend for the lunar node for the beginning of *śaka* 1425 comes out to be 1°58'46'', not 4°3'32''.

However, the multiplier and the addend given here are very close to what we get when using the parameters given by Bhāskara II in the *Siddhāntaśiromaṇi*. Using these parameters, we get 19°21'33"21''' as the multiplier for the lunar node, and 3°16'2'' as the addend corresponding to the beginning of *śaka* 1425.

Why a different epoch is introduced here, and why different parameters are used is unclear.

~ SOME FORMULAE ~

(3^{c-d}) [The longitude of the lunar node] increased by 20 degrees of the Sun's entry into a sign [?] [which is itself] increased by 13 degrees [or: when greater than 13 degrees]. The lunar latitude is [equal to] half of the degrees of the arc of the Sun increased by the node is multiplied by 3 and increased by 30 degrees.

The content of *pāda* c could be an eclipse limit (the subject of the sentence being the shadow of the Earth), but the interpretation is not clear. In *pāda* d, we are given a formula for the lunar latitude, but the formula is defective as described.

~ TO FIND THE APPARENT DIAMETERS FROM THE VELOCITIES ~

(4) The [true] velocity [of the Sun] is divided by 5. [The result is] diminished by its own twelfth part. [This] is [the diameter of] the [apparent] disc of the Sun.

[The apparent diameter of] the disc of the Moon is 649 divided by the star-eaten [?].

That [apparent diameter of the disc of the Moon] is multiplied by 3, and [the result] is increased by its own tenth part and diminished by the seventh part of the [true] velocity of the Sun. [This] is [the apparent diameter of] the shadow of the Earth.

The [true] velocity of the Moon is [equal to] the [apparent diameter of] the disc [of the Moon] divided by 74.

This verse gives formulae for computing the diameters of the discs of the Sun, the Moon, and the shadow of the Earth from the velocities of the Sun and the Moon. Note that as the formulae are given here, the diameters are given in *anṅulas* rather than in minutes of arc, where 1 *anṅula* is equal to 3'. These formulae more properly belong to the chapter on lunar eclipses, but since Jñānarāja does not give them there, a brief discussion is given here.

Note that the diameters of the Sun, the Moon, and the shadow of the Earth depend on the velocities because they depend on their distances to the Earth, and these distances, in turn, depends on the velocities.

In the following, $d_{\odot}$ denotes the diameter of the disc of the Sun, d_{ζ} the diameter of the disc of the Moon, $d_{\oslash}$ the diameter of the shadow of the Earth at the Moon's distance, $v_{\odot}$ the true velocity of the Sun, and v_{ζ} the true velocity of the Moon.

The first formula tells us how to compute the diameter of the disc of the Sun from the true velocity of the Sun:

$$d_{\odot} = \frac{v_{\odot}}{5} - \frac{v_{\odot}}{5 \times 12} = \frac{11}{60} \times v_{\odot}. \quad (6.1)$$

It is given both in the *Śiṣyadhīrvṛddhidatantra* and the *Siddhāntaśiromaṇi*,¹ though both these texts have the diameter expressed in minutes of arc rather than in *anṅulas*.

The second formula is not clear. What exactly is meant by “star-eaten” here is unknown to me. Maybe a formula like

$$d_{\zeta} = \frac{v_{\zeta} - 715}{25} + 29, \quad (6.2)$$

which is given in the *Siddhāntaśiromaṇi*,² is intended.

The third formula allows us to compute the diameter of the shadow of the Earth at the Moon's distance from the diameter of the disc of the Moon and the true velocity of the Sun:

$$d_{\oslash} = 3 \times d_{\zeta} + \frac{3}{10} \times d_{\zeta} - \frac{1}{7} \times v_{\odot} = \frac{33}{10} \times d_{\zeta} - \frac{1}{7} \times v_{\odot}. \quad (6.3)$$

If we use the result in the next formula, that $d_{\zeta} = \frac{1}{74} \times v_{\zeta}$, we get

$$d_{\oslash} = \frac{33}{740} \times v_{\zeta} - \frac{1}{7} \times v_{\odot}, \quad (6.4)$$

¹*Śiṣyadhīrvṛddhidatantra* 5.9. *Siddhāntaśiromaṇi*, *grahagaṇitādhyāya*, *candragrahaṇādhikāra*, 8.

²*Siddhāntaśiromaṇi*, *grahagaṇitādhyāya*, *candragrahaṇādhikāra*, 8.

which, expressed in minutes of arc rather than in *aṅgulas*, become

$$d_{\odot} = \frac{99}{740} \times v_{\zeta} - \frac{3}{7} \times v_{\odot}. \quad (6.5)$$

Since $\frac{99}{740} \approx \frac{2}{15}$ and $\frac{3}{7} \approx \frac{5}{12}$, this is consistent with the formula

$$d_{\odot} = \frac{2}{15} \times v_{\zeta} - \frac{5}{12} \times v_{\odot}, \quad (6.6)$$

which is given in the *Siddhāntaśiromaṇi*.³

The final formula given in the verse,

$$v_{\zeta} = 74 \times d_{\zeta}, \quad (6.7)$$

is given in the *Siddhāntaśiromaṇi*,⁴ though expressed in terms of minutes of arc rather than in *aṅgulas* there.

~ DURATION AND OBSCURATION OF AN ECLIPSE ~

(5) The square root of the difference of the square of half the sum of the diameters [of the discs] and the square of the lunar latitude is multiplied by 60 and divided by the difference of the velocities. [The result] is the *ghaṭikās* of the half-duration [of the eclipse]. [When] the time of the syzygy is diminished or increased by that [half-duration], it is the time of first contact or the time of release [respectively]. Half of the sum of [the diameters of] the discs diminished by the lunar latitude is the obscured [part at mid-eclipse].

All these results are repeated again in the next chapter, where they properly belong. For a discussion, see 2.5.15, 2.5.17, and 2.5.14^{c-d}, as well as the commentaries thereon.

Note that as formulated here, i.e., without specifying what discs and velocities are involved, the formulae are applicable to both lunar and solar eclipses.

~ TO COMPUTE A SOLAR ECLIPSE AND LATITUDINAL PARALLAX ~

(6) The hour-angle multiplied by 4 and divided by half [of the length] of the given day is applied positively or negatively to the time of conjunction according to [whether the Sun is in] the western or the eastern hemisphere. [This process is to be carried out] thus again [and again], until [the time of conjunction is] correct.

³*Siddhāntaśiromaṇi*, *grahagaṇitādhyāya*, *candragrahaṇādhikāra*, 9.

⁴*Siddhāntaśiromaṇi*, *grahagaṇitādhyāya*, *candragrahaṇādhikāra*, 8.

[When the longitude of] the ascendant [is] diminished by three signs[, the result is the nonagesimal, which is taken as being equal to the meridian ecliptic point]. The Small Sine of the combination of the degrees of the declination of that [meridian ecliptic point] and the degrees of the local latitude is divided by 10 and increased by itself below. [The result] is the latitudinal parallax. One should correct the lunar latitude by means of it.

This verse is a somewhat confusing version of some of the results of the chapter on solar eclipses. Again, the material given here belongs more properly to another chapter.

The hour-angle is the angular distance between the position of the Sun and the meridian, measured as an arc on the celestial equator, which we can take to be the difference between the longitude of the Sun and the longitude of the meridian ecliptic point (the intersection between the local meridian and the ecliptic). Then the first half of the verse mirrors 2.6.11–2.6.12^b, except that the longitudinal parallax applied consists only of the small longitudinal parallax defined in 2.6.9^c–2.6.10^b (with the longitude of the meridian ecliptic point λ_M instead of the longitude of the nonagesimal λ_V). If a denotes half the length of the arc of the diurnal circle that is above the horizon, π_λ denotes the small longitudinal parallax, and $\lambda_\odot$ the longitude of the Sun, we here have

$$\pi_\lambda = \frac{4 \times (\lambda_M - \lambda_\odot)}{a}, \quad (6.8)$$

whereas we have

$$\pi_\lambda = \frac{4 \times \text{Sin}(\lambda_V - \lambda_\odot)}{R} \quad (6.9)$$

in 2.6.9^c–2.6.10^b. Using only the small longitudinal parallax implies a situation where the zenith and the nonagesimal coincide. The reader is referred to the discussion there, as well as to a comparison with verses 3–5 in the *parvasambhava* section in the *Siddhāntaśiromaṇi* of Bhāskara II.

The second half of the verse tells us how to compute the latitudinal parallax π_β , and that this is to be used to correct the lunar latitude. First we are directed to find the longitude of the nonagesimal, which is the longitude of the ascendant (the rising point of the ecliptic on the horizon) diminished by three signs. The longitude of the nonagesimal is to be taken as equal to the longitude of the meridian ecliptic point. The combination of the declination of the meridian ecliptic point and the local latitude is the zenith distance of the meridian ecliptic point (see 2.6^{c-d}).

The meaning of the quantity being “increased by itself below” must be that it is increased by itself separately and then the sum is added to the original number. In other words, from x , we get $3 \times x$. With this interpretation, we get

$$\pi_\beta = \frac{3}{10} \times \text{Sin}^\ell(z_M), \quad (6.10)$$

which is the same result as that in 2.10^{c-d}, since

$$\frac{\text{Sin}(z_M)}{70} = \frac{3438}{160 \times 70} \times \text{Sin}^\ell(z_M) \approx \frac{3}{10} \times \text{Sin}^\ell(z_M). \quad (6.11)$$

For more details, the reader is referred to the discussion of parallax in the section on solar eclipses.

~ CONCLUDING VERSE ~

(7) Thus the occurrence of eclipses accompanied by demonstration is given in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 7

grahagaṇitādhyaṃya section 5

candragrahaṇādhikāra

Lunar eclipses

~ DIFFERENT OPINIONS ON THE CAUSE OF ECLIPSES ~

(1–2) The cause of eclipses of the Sun and the Moon is said by sages to be a darkness, the body of which is divided into a head and a tail, and which dwells at the two intersections between the ecliptic and the inclined orbit [of the Moon].

[However,] the cause of eclipses of the Sun and the Moon is said by people who oppose *śruti* and the *purāṇas* to be the Moon and the shadow of the Earth, respectively. They even say that in their opinion an eclipse is not [caused] by Rāhu.

According to an ancient story recorded in the *purāṇas*, solar and lunar eclipses are caused by a supernatural being called Rāhu, who attacks the Sun and the Moon. The Indian astronomers understood the actual reason that eclipses occur, namely that the disc of the Moon is obscured by the shadow of the Earth during a lunar eclipse and that the disc of the Sun is obscured by the disc of the Moon during a solar eclipse. The idea that eclipses are caused by Rāhu is refuted by Lalla in the *Śiṣyadhīvrddhidatantra*.¹ However, with the greater Indian tradition holding that Rāhu causes eclipses, the astronomers felt uneasy rejecting it altogether. In the *Brāhmasphuṭasiddhānta*,

¹*Śiṣyadhīvrddhidatantra* 20.17–27.

Brahmagupta, after explaining the true cause of eclipses and denying Rāhu's involvement,² rejects this opinion, which he ascribes to other astronomers, and continues to argue that Rāhu does indeed cause eclipses.³ Pṛthūdakasvāmin, the commentator on the *Brāhmasphuṭasiddhānta*, suggests that Brahmagupta does this because that which is repugnant to the people should not be mentioned.⁴ Here and in the following verses, Jñānarāja argues that Rāhu is indeed the cause of eclipses.

Rāhu's tail is called Ketu.⁵

~ APPARENT AND REAL CAUSES OF RĀVAṆA'S DEATH ~

(3-4) Learned men say that although the ten-headed [Rāvaṇa] was killed by the arrow of [Rāma,] the son of Daśaratha, the ten-headed [Rāvaṇa] was [in fact] killed by [Rāma,] the son of Daśaratha; people [versed in] the *purāṇas* likewise [say this].

[Likewise,] even if the two eclipsing bodies are the shadow of the Earth and the Moon, still the cause [of an eclipse] is Rāhu. Because after drawing the Moon near by means of the lunar latitude, he causes the conjunction of the eclipsing body and the eclipsed body.

As is well-known in Indian mythology, Rāvaṇa, the King of Laṅkā, was killed by the arrow of the deity Rāma. However, while it was the arrow that killed Rāvaṇa, the real cause was Rāma, who fired the arrow.

Just as Rāma is the real cause of Rāvaṇa's death, the arrow being merely an instrument, so also is Rāhu the real cause of eclipses. It is Rāhu who draws the Moon near and thus causes the conjunction of the eclipsing body and the eclipsed body.

Note that Jñānarāja here tries to reconcile ideas from the *purāṇas* with his astronomical model. See p. 49 in the Introduction.

~ IDENTITY OF RĀHU AND THE LUNAR NODE ~

(5) He, whose name is given as “lunar node” by great men, is [also] called “Rāhu” by them. When there is a rejection of him, there would always be an eclipse of the Sun and the Moon each month.

²*Brāhmasphuṭasiddhānta* 21.35–38.

³*Brāhmasphuṭasiddhānta* 39–48.

⁴Commentary on *Brāhmasphuṭasiddhānta* 21.43^{a-b} (see [41 . 131]).

⁵See [76 . 275].

Luminary	Diameter
The Sun	6500
The Moon	480

Table 7.1: Diameters in *yojanas* of the discs of the Sun and the Moon

After stating that “Rāhu” and “lunar node” are two names for the same thing or personage, Jñānarāja argues that if Rāhu is rejected as the cause of eclipses, there would be a solar and a lunar eclipse every month. The idea, as per the previous verse, is that it is Rāhu that pulls the Moon towards the ecliptic by means of the lunar latitude, and without this pull, the Moon would move in a way so that there would be a solar and a lunar eclipse each month. But this is not what we experience. This is an odd statement, though, as it implies that Rāhu keeps the Moon off the ecliptic.

~ THE SHADOW AND THE MOON AS RĀHU’S INSTRUMENTS ~

(6) **The disc of the shadow of the Earth and the disc of the Moon, which can be used for obscuring, are [merely] the weapons of Rāhu during the act of an eclipse. Therefore, they are not mentioned in the *purāṇas*, the *āgamas*, and the *saṃhitās*, but they are indicated in the *veda*.**

Since the shadow of the Earth and the disc of the Moon are merely the weapons of Rāhu, they are not mentioned in the *purāṇas* and other sacred texts, such as the *āgamas* and the *saṃhitās*. However, according to Jñānarāja, they are alluded to in the *vedas*.

~ DIAMETERS OF THE SOLAR AND LUNAR DISCS ~

(7^{a-b}) **The solar disc has [a diameter of] 6500 *yojanas*, and the disc of the Moon has [a diameter of] 480 *yojanas*.**

Table 7.1 gives the values of the diameters of the solar and lunar discs in *yojanas* given in by Jñānarāja. They are the same as those given in the *Sūryasiddhānta*.⁶ Jñānarāja will give a procedure for how to determine these numbers from observation in verse 9.

To avoid confusion with the apparent diameters used in eclipse computations, the values given here will be called mean diameters in the following.

⁶See [71 . 616].

~ TO FIND THE TRUE DIAMETERS ~

(7^{b-c}) The [diameter of a luminary] is multiplied by the true velocity [of the luminary] and divided by the mean velocity [of the luminary]. The apparent diameter [is found] thus.

Neither the Sun nor the Moon changes its size, but as their distances to the Earth vary, their apparent sizes vary as well.

Let $\bar{d}$ denote the mean diameter of the Sun, $\bar{v}$ the Sun's mean velocity (measured in *ghaṭikās* per civil day), and v its true velocity. Then the apparent diameter d is given by a simple proportion:

$$d = \bar{d} \times \frac{v}{\bar{v}}. \quad (7.1)$$

The apparent diameter of the Moon is computed in the same way.

~ TO FIND THE DIAMETER OF THE EARTH'S SHADOW ~

(8) The [diameter of the] disc of the Moon is multiplied by the difference of the diameters of the Sun and the Earth and divided by [the diameter of] the disc of the Sun. The diameter of the Earth diminished by the result is [the diameter of the] shadow of the Earth [at the Moon's distance]. [When this diameter is] divided by 15, it is [measured] in minutes of arc and so on.

As will be explained in verse 10, the light from the Sun creates a shadow in the form of a cone on the other side of the Earth. When the Moon passes through this shadow, a lunar eclipse (partial or total, as the case may be) occurs. In order to carry out the computations for a lunar eclipse, it is necessary to know the diameter of the shadow of the Earth at the distance at which the Moon passes through it.

Let $d_{\oplus}$, $d_{\odot}$, and $d_{\text{☾}}$ be the diameters of the Earth, the Sun, and the Moon, respectively, in *yojanas*. In addition, let $d_{\text{☾}}$ be the diameter of the shadow of the Earth at the distance of the Moon. The formula given for computing this diameter is:

$$d_{\text{☾}} = d_{\oplus} - (d_{\odot} - d_{\oplus}) \times \frac{d_{\text{☾}}}{d_{\odot}} \quad (7.2)$$

The rationale behind this formula is given in verses 11–12 by Jñānarāja, at which place a discussion of it is found. See also Figure 7.1.

If we insert the mean diameters of the Sun and the Moon, and use that the diameter of the Earth is 1600 *yojanas* (the radius of the earth, which we will denote by $r_{\oplus}$, is 800 *yojanas*⁷), we find that

⁷I have no direct reference in the *Siddhāntasundara* to this effect, but the number 800 is added to 2.6.4 as numerals by most scribes, and it further follows from the circumference of the earth being given as 5,059 *yojanas* in 1.1.74 (using $\pi = \sqrt{10}$). The *Sūryasiddhānta* also gives 800 *yojanas* as the radius of the earth.

the mean diameter of the shadow of the Earth at the Moon's distance measured in *yojanas* is

$$\bar{d}_{\Omega} = 1600 - (6500 - 1600) \times \frac{480}{6500} = 1238\frac{2}{13}, \quad (7.3)$$

i.e., a bit more than $2\frac{1}{2}$ times the mean diameter of the Moon.

Rather than using *yojanas*, we want to express the diameters in minutes of arc. As there are 15 *yojanas* in a minute of arc of the lunar orbit,⁸ dividing the *yojanas* of the diameters by 15 will convert them to minutes of arc.

~ TO FIND THE APPARENT DIAMETER FROM OBSERVATION ~

(9) Having learned the amount of *asus* in the rising [time] of the discs of the Moon and the Sun [at a time] when [each, separately, travels with its] mean velocity, the orbit [of the respective luminary] is multiplied by that and divided by the *asus* in a nychthemeron. By the application of this proportion, the *yojanas* in the respective disc [are found].

The procedure described here is to be carried out for both the Sun and the Moon, and will give the diameters of their discs. Let us take the Moon as the example in the following. At a time when the Moon is moving with its mean velocity, the time it takes for its disc to rise is measured. Jñānārāja uses the time unit *asu* (literally, breath), which is equal to $\frac{1}{3600}$ of a *ghaṭikā*, for measuring the rising time. Let the time of the rising of the disc be τ , and let t be the 21600 *asus* in a nychthemeron. Further, let $\bar{d}$ be the mean diameter of the Moon, and K the *yojanas* in the orbit of the Moon. Then the proportion

$$\frac{\tau}{t} = \frac{\bar{d}}{K} \quad (7.4)$$

gives us the mean diameter.

Note that it is necessary for the Moon to travel at its mean velocity to get the mean diameter. Otherwise, we will get the apparent diameter current at that time, and will need to know the true velocity of the Moon in order to find the mean diameter. See Equation 7.1.

Pṛthūdakasvāmin gives a similar procedure for finding the mean diameter of the Moon in his commentary on the *Brāhmasphuṭasiddhānta*, only he directs that one carry out the procedure every day during a lunar month and find the average rising time, which is then used to determine the mean diameter of the Moon's disc.⁹

⁸See [71 . 556].

⁹Commentary on *Brāhmasphuṭasiddhānta* 21.11^{a-b}. See [41 . 193].

~ TO COMPUTE THE DIAMETER OF THE SHADOW ~

(10) The measure at the orbit of the Moon of the diameter of the cone-shaped shadow [produced] from the contact of the rays emanating from the Sun and the surface of the Earth and situated in space six [signs removed] from the Sun is to be computed by the wise in the manner of the computation of the shadow [created] by a lamp.

The rays of the Sun hit the surface of the Earth, which blocks them, thus creating a cone-shaped shadow on the other side of the Earth. See Figure 7.1. It is clear that the center of the shadow is located on the ecliptic at exactly six signs from the Sun.

Jñānarāja says that the computation of the diameter of the shadow at the Moon's distance from the Earth is like that of the computation of the shadow made by a lamp.

There is a figure illustrating this verse in R_1 , a scan of which is given in the description of that manuscript in the Introduction (see p. 55).

~ METHOD FOR COMPUTING THE DIAMETER OF THE SHADOW ~

(11–12) If the difference of the radii of [the discs of] the Sun and the Earth is the upright [corresponding to] the leg equal to the geocentric distance of the Sun, then what is [the upright] when the leg is [a length inside] the shadow [of the Earth], the measure of which is the mean geocentric distance of the Moon? The result is at the place of the Moon [i.e., it is on the orbit of the Moon], and is half the diameter of the Earth diminished by radius of the shadow of the Earth [at the distance of the Moon].

[Having arrived at a formula] thus, here, having divided the two geocentric distances [involved in the preceding] by an [appropriate] number, [the results] are [the diameters of] the discs [of the Sun and the Moon], which are, respectively, the multiplier and the divisor [in the resulting formula].

The method is illustrated in Figure 7.1. On the figure, S is the center of the Sun, E the center of the Earth, and M marks the distance between the center of the Earth and the Moon's orbit along a line through the center of the Sun. The orbit of the Moon is indicated through the point M .

Let $r_{\odot}$ be the radius of the Sun, $r_{\oplus}$ be the radius of the Earth, $r_{\oslash}$ the radius of the shadow of the Earth at M , $D_{\odot}$ the geocentric distance of the Sun, and $D_{\oslash}$ the geocentric distance of the Moon.

On the figure, the right-angled triangle SAE is similar to the right-angled triangle EBM , and

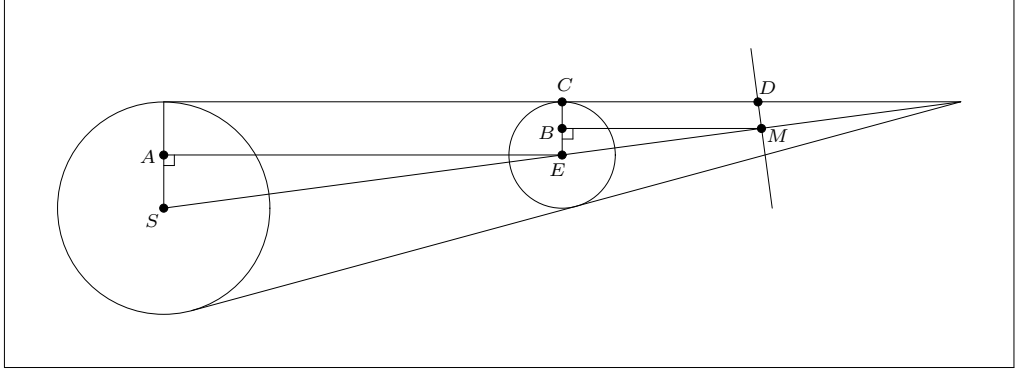


Figure 7.1: Determining the radius of the shadow of the Earth at the Moon's distance

therefore

$$\frac{|SA|}{|SE|} = \frac{|EB|}{|EM|}. \quad (7.5)$$

Here, $|SA| = r_{\odot} - r_{\oplus}$, $|SE| = D_{\odot}$, and $|EM| = D_{\mathcal{L}}$. The radius of the shadow is $|MD|$, and if we assume that the line MD is perpendicular to the line EM , we further have that $|EB| = r_{\oplus} - r_{\mathcal{L}}$. From this we get that

$$\frac{r_{\odot} - r_{\oplus}}{D_{\odot}} = \frac{r_{\oplus} - r_{\mathcal{L}}}{D_{\mathcal{L}}}, \quad (7.6)$$

which, after rearranging the terms and multiplying by 2, becomes

$$d_{\mathcal{L}} = d_{\oplus} - \frac{D_{\mathcal{L}}}{D_{\odot}} \times (d_{\odot} - d_{\oplus}). \quad (7.7)$$

Finally, Jñānarāja notes that if divided by an appropriate number, $D_{\odot}$ and $D_{\mathcal{L}}$ become $\bar{d}_{\odot}$ and $\bar{d}_{\mathcal{L}}$, which is approximately correct. In fact, $D_{\odot} \approx 106 \times \bar{d}_{\odot}$, and $D_{\mathcal{L}} \approx 107\frac{1}{2} \times \bar{d}_{\mathcal{L}}$. That

$$\frac{D_{\odot}}{\bar{d}_{\odot}} \approx \frac{D_{\mathcal{L}}}{\bar{d}_{\mathcal{L}}} \quad (7.8)$$

is due to the fact that the discs of the Sun and the Moon, as seen on the sky from the Earth, have roughly the same size. Using this proportion, we get

$$d_{\mathcal{L}} = d_{\oplus} - \frac{\bar{d}_{\mathcal{L}}}{\bar{d}_{\odot}} \times (d_{\odot} - d_{\oplus}), \quad (7.9)$$

which is the formula of verse 8.

Note that MD (the path of the Moon through the shadow of the Earth) really is an arc, not a straight line. However, given the distance of the Moon from the Earth, the arc can approximately be taken to be a straight line.

The Sanskrit words *śruti*, *śravaṇa*, and *karṇa*, all of which mean “hypotenuse”, are used as a term for the geocentric distance of a heavenly body.

I have taken the words *dineśaśrutitulyabhāyāḥ* in the sense of “a leg equal to the geocentric distance of the Sun.” This length, however, is not a shadow (*bhā*).

~ TO FIND THE LONGITUDES AT THE TIME OF CONJUNCTION ~

(13) The minutes of arc in the velocity [of the shadow of the Earth or the Moon] are multiplied by the *ghaṭikās* corresponding to the end of the *tithi* and divided by 60. [The longitude of] the shadow of the Earth and [the longitude of] the Moon are diminished [or increased] by the result. At the end of the *tithi*, the two of them are together, having the same minutes of arc.

The methods in the *Siddhāntasundara* give us planetary positions for midnight. In order to find the longitude at the end of the *tithi*, i.e., at conjunction, we have to take into account the distance traveled by the shadow of the Earth and the Moon between conjunction and the time for which we have the computed positions.

Let $v_{\odot}$ be the velocity of the shadow of the Earth (which is the same as the velocity of the Sun) and $v_{\text{☾}}$ be the velocity of the Moon. Assume that there are t *ghaṭikās* between the time for which we have the longitudes and the time of conjunction. The shadow of the Earth travels $v_{\odot} \times \frac{t}{60}$ minutes of arc and the Moon $v_{\text{☾}} \times \frac{t}{60}$ during the time t . If the time for which we have the longitudes comes after the conjunction, we have to subtract the respective results from the longitude of the shadow of the Earth and the longitude of the Moon; if it comes before, we have to add them. After this operation, we have the longitudes of the shadow of the Earth and the Moon at the time of conjunction; the two are equal at the time of conjunction.

For the given translation, I have read *śaśī tau* in *pāda c* instead of *śaśī nau*, which is given in all of the manuscripts. The latter reading makes less sense, as the Moon (*śaśīn*) and the Sun (*ina*) are not together (*sahita*) at the time of opposition, but 180° apart. One wonders if *sahitau* should be read *sahito* and thus supply the missing “or increased” in the verse.

~ TO FIND THE LUNAR LATITUDE ~

(14^{a-b}) The Sine produced from the arc [equal to the longitude] of the Moon diminished by [the longitude of] the shadow of the Earth is multiplied by 270 and divided by the radius. [The result] is the latitude of the Moon, the direction of which is determined by the hemisphere of [the longitude of] the Moon diminished by [the longitude of] the shadow of the Earth.

In the Indian astronomical system, the Moon moves in an orbit that is inclined with respect to the ecliptic. It is called the inclined orbit of the Moon. The inclined orbit intersects the ecliptic at two positions that are 180° from each other. The point of intersection through which the Moon crosses the ecliptic moving north is called the ascending node, and the other one is called the descending node. The angle between the position of the Moon and the ecliptic is called the lunar latitude, which will be denoted by β in the following.

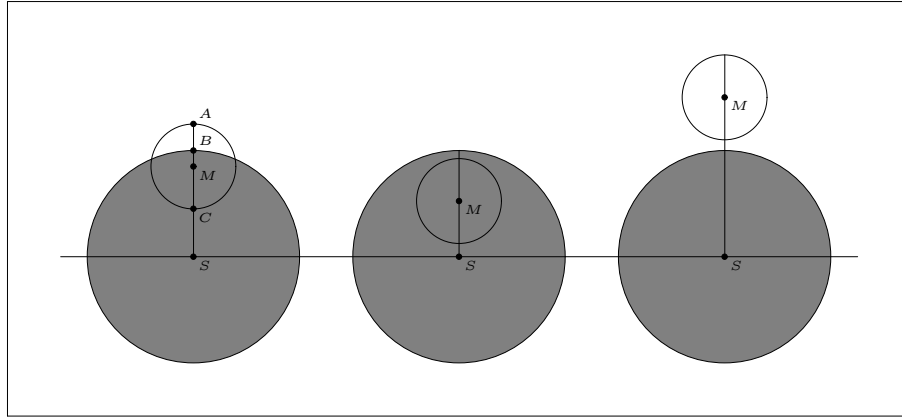


Figure 7.2: Examples of the obscured part of the lunar disc at mid-eclipse

The angle between the circle of the ecliptic and the circle of the inclined orbit of the Moon is $4^{\circ}30' = 270'$. This means that the greatest lunar latitude, which is attained when the Moon is 90° from one of its nodes, is $270'$. For other positions of the Moon, the lunar latitude, measured in minutes of arc, is found by a simple proportion:

$$\beta = \text{Sin}(\lambda_{\zeta} - \lambda_{\odot}) \times \frac{270}{R}, \quad (7.10)$$

where $\lambda_{\odot}$ is the longitude of the ascending node and λ_{ζ} is the longitude of the Moon.

The direction of the latitude is either north or south, depending on where the Moon is with respect to the ascending node. If the Moon is between 0° and 180° from the ascending node (measured in the direction of motion of the Moon), the direction of the latitude is north; if it is between 180° and 360° from the ascending node, the direction is south.

It is essential to know the lunar latitude when computing a lunar eclipse. The lunar latitude tells us how far the Moon is from the ecliptic and thus whether we will have a total eclipse, a partial eclipse, or no eclipse at all.

~ TO FIND THE OBSCURED PART AT MID-ECLIPSE ~

(14^{c-d}) **Half the sum of the measures [of the discs] of the eclipsed body and the eclipsing body is diminished by the lunar latitude. [The result] is the obscured [part]. This [quantity] diminished by [the diameter of the disc of the] eclipsed body is said by the wise to have the name sky-obscured [part].**

Figure 7.2 shows the magnitude of a lunar eclipse at mid-eclipse in three different situations. In each example, S is the center of the shadow of the Earth and M the center of the Moon.

In the first example, we have a partial eclipse. The length of the line CB is called the “obscured part” in the Indian tradition. We take the lunar latitude to be the line segment SM in each case. It is easy to see that

$$|CB| = (|SB| - |SM|) + |CM| = r_{\delta\zeta} + r_{\zeta} - \beta, \quad (7.11)$$

as stated by Jñānarāja. The length of the line BA is called the “sky-obscured” part in the Indian tradition. It is equally easy to see that

$$|BA| = |CA| - |CB| = d_{\zeta} - (r_{\delta\zeta} + r_{\zeta} - \beta) = r_{\zeta} - r_{\delta\zeta} + \beta. \quad (7.12)$$

In the second example, we have a total eclipse. In this case, following the formula given by Jñānarāja, the obscured part is greater than or equal to d_{ζ} . What this means is that the obscured part tells us how deep the Moon is inside the shadow.

In the third and last example, the Moon is too far from the ecliptic for there to be an eclipse.

~ HALF-DURATION OF THE ECLIPSE AND OF TOTALITY ~

(15–16) **The square root of the difference of the square of half of the sum [of the diameters] of the discs [of the Moon and the shadow of the Earth] and the lunar latitude is multiplied by 60 and divided by the [true] velocity of the Moon diminished by that of the Sun. The result is half of the duration of a lunar eclipse.**

Likewise, the mean half-duration of totality is [found] from the difference of the halves of the measures [of the diameters of the discs].

The half-duration computed from the lunar latitude current at the time of first contact or release is correct.

The eclipse commences when the disc of the Moon first touches the disc of the shadow of the Earth. For this to happen, the Moon must be sufficiently close to the ecliptic. When the Moon is first completely inside the shadow (still touching the edge of the shadow), it is said to be the beginning of totality. In other words, when the Moon first touches the shadow, it is the beginning of the eclipse, and when it is first entirely covered by the shadow, it is the beginning of totality.

Let r_{ζ} and $r_{\delta\zeta}$ be the radii of the Moon and the shadow of the Earth, respectively. Let v_{ζ} and $v_{\odot}$ be the velocities of the Moon and the Sun, respectively (note that the shadow of the Earth moves with the same velocity as the Sun). Let finally β be the lunar latitude. Then half the duration of the eclipse is given by

$$\frac{60 \times \sqrt{(r_{\delta\zeta} + r_{\zeta})^2 - \beta^2}}{v_{\zeta} - v_{\odot}}, \quad (7.13)$$

and half the duration of totality is given by

$$\frac{60 \times \sqrt{(r_{\odot} - r_{\text{L}})^2 - \beta^2}}{v_{\text{L}} - v_{\odot}}. \quad (7.14)$$

The first of these results is derived by Jñānarāja in verses 18–19, and the commentary on these verses explains them both.

As the lunar latitude changes throughout the eclipse, we need to use the correct lunar latitude at first contact, beginning of totality, and so on in order to get the correct times.

~ TO FIND WHEN THE ECLIPSE AND TOTALITY BEGIN AND END ~

(17) When the time of the end of the *tithi* is diminished or increased by the [half-]duration, [the result is], respectively, [the time of] first contact and [the time of] release.

Likewise, when it is diminished or increased by the half-duration of totality, [the result is, respectively], the time of beginning of totality and the time of end of totality.

The moment of conjunction is mid-eclipse. It also occurs at the end of a *tithi*. If we assume that mid-eclipse occurs precisely at the middle of the eclipse (with respect to time), then it is clear that adding or subtracting the half-duration to or from mid-eclipse yields the end and the beginning of the eclipse. Similarly for the end and the beginning of totality.

~ DERIVING THE FORMULAE FOR THE HALF DURATIONS ~

(18–19) The center of the shadow of the Earth is on the ecliptic and the center of the Moon is at the tip of the lunar latitude on its latitude circle [i.e., its inclined orbit]. At first contact, the two are at a distance equal to half of the sum of the measures [of the diameters of their discs from each other]. At mid-eclipse, they are at a distance equal to the lunar latitude [from each other]. Therefore, the hypotenuse in the [first] case is equal to half of the sum of the measures [of the diameters of the discs], the upright is the lunar latitude, and the leg is the square root of the difference of the squares [of the hypotenuse and the upright]. The half-duration [of the eclipse] is that [leg], which, after [the application of] a proportion involving the velocity of the Moon diminished by that of the Sun, has the form of *ghaṭikās*.

Jñānarāja here derives one of the two formulae from verses 15–16. On Figure 7.3, M_1 is the

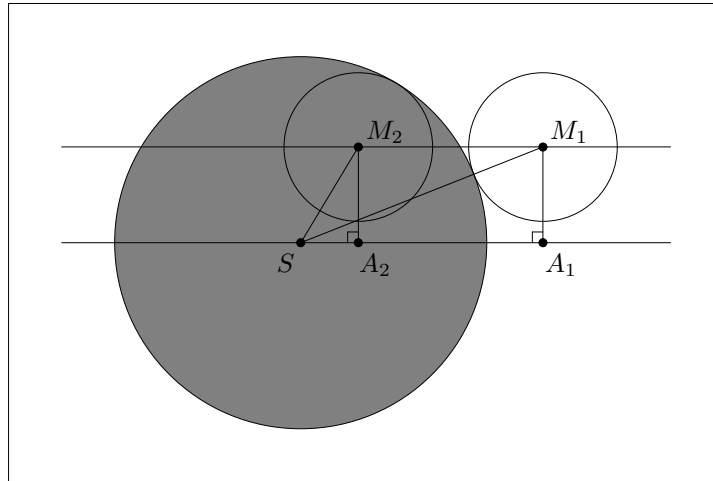


Figure 7.3: Finding the half duration of the eclipse and the half duration of totality

position of the center of the Moon at first contact and M_2 is the position at the beginning of totality. The line M_2M_1 is the orbit of the Moon and the line SA_2A_1 is the ecliptic. They are parallel, indicating that we are assuming that the lunar latitude remains constant during the eclipse.

Notice that $SM_1 = r_{\odot} + r_{\text{L}}$ and $SM_2 = r_{\odot} - r_{\text{L}}$. We will restrict ourselves to working out the formula for first contact; the procedure is analogous for the beginning of totality.

From the Pythagorean theorem we get that

$$|SA_1| = \sqrt{|SM_1|^2 - |M_1A_1|^2} = \sqrt{(r_{\text{L}} + r_{\odot})^2 - \beta^2}. \quad (7.15)$$

Since the velocity of the Moon with respect to the shadow of the Earth is $v_{\text{L}} - v_{\odot}$, it takes the Moon

$$60 \times \frac{\sqrt{(r_{\text{L}} + r_{\odot})^2 - \beta^2}}{v_{\text{L}} - v_{\odot}} \quad (7.16)$$

ghaṭikās to travel the distance $|SA_1|$. The formula follows from this.

~ THE AMOUNT OF OBSCURATION AT A GIVEN TIME ~

(20–21) If the measure of obscuration at a given time is computed from [the time of] first contact or from [the time of] release], then the velocity of the Moon diminished by that of the Sun is multiplied by the *ghaṭikās* in the difference of the half-duration and the given [time] and divided by 60. The result is the leg. The [corresponding] upright is the latitude current at the given time, and the hypotenuse is the square root of the sum of the squares of those [two quantities].

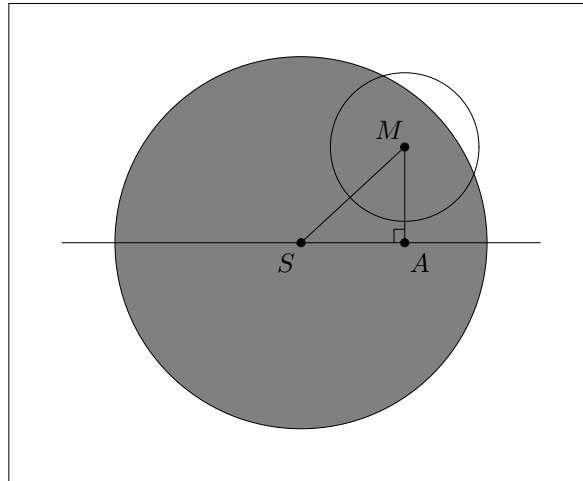


Figure 7.4: Finding the obscuration at a given time

The amount [equal to] half of the sum of the measures [of the diameters of the discs] diminished by the hypotenuse is considered to be obscured.

Let τ be the given time between the beginning and the end of the eclipse and t the half-duration, both measured in *ghaṭikās*, and consider Figure 7.4 (where the given time corresponds to the lunar latitude being AM). Since the Moon travels the distance SA in the time $t - \tau$, it is clear that

$$|SA| = \frac{(t - \tau) \times (v_{\mathcal{L}} - v_{\odot})}{60}, \quad (7.17)$$

where we divide by 60 because the velocities are given with respect to civil days. This is the leg in the right-angled triangle SAM , the upright of which is $AM = \beta$. The hypotenuse is then

$$|SM| = \sqrt{|SA|^2 + |AM|^2} = \sqrt{\left(\frac{(t - \tau) \times (v_{\mathcal{L}} - v_{\odot})}{60}\right)^2 + \beta^2}. \quad (7.18)$$

The obscured portion of the disc of the Moon at the given time is then defined as $r_{\mathcal{L}} + r_{\odot} - h$.

As in the case of mid-eclipse, the obscured portion at a given time can be larger than the disc of the Moon itself. In that case, as before, the obscured portion tells us how deep the disc is inside the shadow.

~ INTRODUCING THE VALANAS ~

(22) **An observer has a need for first contact, mid-eclipse, and release, which are lying on the east-west [line] on the disc on its own account. Therefore, for the sake of computing directions, I will now explain the *valanas*.**

The Sanskrit term *valana* is generally translated as “deflection”. The *valana* is the angle between the ecliptic and an “east-west” line on the disc of the Moon. This “east-west” line is perpendicular to the the great circle through the center of the Moon and the north and south points on the local horizon.¹⁰ This concept serves only divinatory purposes and has no astronomical value.¹¹

~ THREE TYPES OF VALANA ~

(23) One *valana* is caused by terrestrial latitude. The second is produced from the pair of *ayanas* [i.e., where the bodies are with respect to the celestial equator], and the third is what is called latitudinal parallax in a solar eclipse.

Normally Indian astronomical texts operate with only two components of *valana*,¹² the *akṣa-valana*, due to the latitude of the observer’s location, and the *ayana-valana*, due to the declination of the bodies. It is peculiar that Jñānarāja here includes latitudinal parallax as a *valana* for a solar eclipse.¹³

~ CONCERNING THE VALANA ~

(24–25) With a motion along the ecliptic, the eclipsing body ... east-west. It is said that when there is no lunar latitude, it obscures the disc. Therefore, it is on its own east-west line [?].

At mid-eclipse, the *valana*, which is the distance [?], is corrected by me. As such, it is clear and explained. At the rise of the lunar latitude from the tip of the *valana*, having given that [*valana?*], one should indicate it on the course of first contact and release.

In these two verses Jñānarāja is giving an explanation of the *valana*. However, the meaning is not clear. There appears to be a corruption in *pāda* b of verse 24.

~ TO COMPUTE THE AYANAVALANA ~

(26) The Sine of the precessional [longitude of a] planet increased by three signs is multiplied by the Sine of 24 degrees and divided by the radius.

¹⁰See [71 . 549].

¹¹See [105 . 238].

¹²See [71 . 549] and [105 . 238–239].

¹³For latitudinal parallax in a solar eclipse, see the commentary on 2.6.2^{a–b}.

The arc corresponding to that [result] is the *ayana*[-*valana*], which has the [same] direction [as that] of the planet increased by three signs.

The formula given for the *ayanavalana* is

$$\text{Sin}(\lambda^* + 90^\circ) \times \frac{\text{Sin}(24^\circ)}{R}, \quad (7.19)$$

where λ^* is the precessional longitude of the planet. It is sometimes given using $\text{Vers}(\lambda^* + 90^\circ)$ instead of $\text{Sin}(\lambda^* + 90^\circ)$,¹⁴ but Bhāskara II rejects the use of the Versed Sine here.¹⁵

~ TO COMPUTE THE AKṢAVALANA ~

(27) The equinoctial shadow is multiplied by the Sine of the hour-angle and divided by the equinoctial hypotenuse. The *akṣavalana* is given by the degrees of the arc corresponding to the result. [Last part of the verse not clear.]

Let d denote the hour-angle (i.e., the depression from the meridian), s_0 the equinoctial shadow, and h_0 the equinoctial hypotenuse. The formula given for the *akṣavalana* is

$$\text{Sin}(d) \times \frac{s_0}{h_0}. \quad (7.20)$$

The last part of the verse is not clear.

~ TO COMPUTE THE TOTAL VALANA ~

(28) When their directions are the same or different, take the sum and the difference, respectively, of the two *valanas*. The Sine of the result is divided by the radius and multiplied by half of the sum of the measures [of the diameters of the discs]. [This] is the true *valana*.

This agrees with what Bhāskara II states in *Karaṇakutūhala* 4.16.

~ AYANAVALANA ON THE TERRESTRIAL EQUATOR ~

(29–30^b) For [the sake of] understanding [of the formulae for the *valanas*], [assume that] the planet is located at one of the solstitial points and is on

¹⁴See, e.g., *Śiṣyadhīvr̥ddhidatantra* 5.25.

¹⁵See *Karaṇakutūhala* 4.3.

the meridian. In this case, the east-west [line] on the disc [of the eclipsed body] along the path of the ecliptic is to be considered the “east-west” [line].

Therefore, on the terrestrial equator, there is no *valana* when the planet is located at one of the solstitial points; when [the planet] is located at the beginning of Libra or at the beginning of Aries, the distance between that [planet] and the east-west line is equal to the degrees of the greatest declination [i.e., the obliquity of the ecliptic].

When the planet is located in an intermediate direction, [the *valana*] is [found] from a proportion. This is the *ayanavalana* [for a location] on the terrestrial equator.

Jñānarāja opens his explanation of the *valana* by stating that when the planet is at one of the solstitial points and on the local meridian, the “east-west” line on the disc of the eclipsed body coincides with the ecliptic. This is so because in this case the great circle through the north and south points of the local horizon and the eclipsed body and the ecliptic are perpendicular to each other.

Let us now assume that we are in a location on the terrestrial equator. If the eclipsed body is at one of the solstitial points, i.e., if its tropical longitude is either 90° or 270° , then there is no *valana*. If, on the other hand, it is at one of the equinoctial points, i.e., if its tropical longitude is 0° or 180° , then the *valana* is equal to the obliquity of the ecliptic. This is easy to see. In the first case, the “east-west” line is the ecliptic, and hence there is no *valana*. In the second case, the “east-west” line is the celestial equator, and hence the *valana* is equal to the angle between the ecliptic and the celestial equator, i.e., the obliquity of the ecliptic.

Let the tropical longitude of the eclipsed body be λ^* and let γ denote the *valana*. For a location on the terrestrial equator, we have that if $\lambda^* = 0^\circ$ or $\lambda^* = 180^\circ$, then $\gamma = \varepsilon$, and if $\lambda^* = 90^\circ$ or $\lambda^* = 270^\circ$, then $\gamma = 0$. From this we get that if $\text{Sin}(\lambda^* + 90^\circ) = 0$, then $\text{Sin}(\gamma) = 0$, and if $\text{Sin}(\lambda^* + 90^\circ) = R$, then $\text{Sin}(\gamma) = \text{Sin}(\varepsilon)$. For a tropical longitude different from the equinoctial and solstitial points, the *valana* is now found from a proportion:

$$\text{Sin}(\gamma) = \text{Sin}(\varepsilon) \times \frac{\text{Sin}(\lambda^* + 90^\circ)}{R}. \quad (7.21)$$

On the terrestrial equator, this is the total *valana*, but elsewhere it is only one out of two components of the *valana*, called the *ayanavalana* and denoted by γ_2 . In general we therefore have that:

$$\text{Sin}(\gamma_2) = \text{Sin}(\varepsilon) \times \frac{\text{Sin}(\lambda^* + 90^\circ)}{R}. \quad (7.22)$$

Note that the Sine of the *ayanavalana* equals the declination of the tropical longitude of the eclipsed body increased by 90° .

~ AKṢAVALANA IN OTHER REGIONS ~

(30^{c-d}) In a region with latitude [i.e., not on the terrestrial equator], considering that it [the *valana*] is affected by the terrestrial latitude, the *akṣavalana* is applied by the ancients.

If one is not on the equator, it is necessary to apply to the *akṣavalana* in addition to the *ayana-valana*.

~ THE AYANAVALANA ~

(31) The ecliptic is to be imagined as resembling the prime vertical. Whatever are the south-north [line] and one's own horizon, the termination of the horizon from that point, that *valana* has the name *ayana* in its own direction.

~ THE AKṢAVALANA ~

(32) On the terrestrial equator, when the planet is on the prime vertical, whatever is the east-west [line] on the disc, that is its own [east-west line]. Therefore, the *akṣavalana* is not produced [for an observer on the terrestrial equator].

On the given horizon, the Sine of the latitude is the distance between them [the terrestrial equator and the given location]; whatever is in between by a proportion, that is said to be the *akṣavalana* by the wise. The *ayana*[-*valana*] is corrected by that.

~ OCCURRENCE OF AN ECLIPSE ~

(33) When for an observer the circle from the center of the eclipsed body, all around by means of half the sum of the apparent diameters, touches the center of the eclipsing body along a line, then there is always an eclipse.

~ PROJECTION DIAGRAM ~

(34) Having put down the *aṅgulas* of the lunar latitude in the opposite

direction of first contact, then the corrected *valana* extends up to the eastern direction on the disc.

~ POSITION OF THE MOON ~

(35) The syzygy is computed along the circle of stars between the marks of the Sun and the Moon. The coming together of the discs is not there, since the Moon is situated at the tip of the lunar latitude. Therefore, for the Moon corrected by the visibility corrections, it is the sum of the discs.

What is not taught by the ancients? We do not know!

~ THE AYANAVALANA USING SMALL SINES ~

(36) The Small Sine of the precessional [longitude of the] Moon increased by three signs is multiplied by 13 and divided by 32. The [Small] Sine of the declination is attained [as the result]. It is multiplied by the lunar latitude and divided by the [Small-Sine] radius. The minutes in the result are applied positively or negatively to the application to [the longitude of] the Moon depending on whether the directions of the lunar latitude and the declination are different or the same. The *tithi* at the syzygy is [determined] from the Moon supplied with the visibility corrections.

If we replace the Sines with small Sines in the formula of verse 26, we get the *ayanaavalana* as

$$\text{Sin}^\ell(\lambda^* + 90^\circ) \times \frac{\text{Sin}^\ell(24^\circ)}{R}. \quad (7.23)$$

Since

$$\frac{\text{Sin}^\ell(24^\circ)}{R} = \frac{64;20}{160} = \frac{193}{480}, \quad (7.24)$$

and

$$\frac{13}{32} - \frac{193}{480} = \frac{1}{240}, \quad (7.25)$$

we see that Jñānarāja's $\frac{13}{32}$ is an approximation $\frac{\text{Sin}^\ell(24^\circ)}{R}$; the formula of the verse follows from this.

~ DRAWING THE ECLIPSE DIAGRAM ~

(37–39) Having put down a circle using a string [measured] by the *aṅgulas*

of the sum of half of the measures [of the diameters of the apparent diameters]. In the computation of the directions, the *valana* current at first contact is to be put down at the eastern [part] of the Moon according to the quarters. The [*valana*] current at release is at the western [part of the Moon]. In the case of a solar eclipse, it is opposite. The two latitudes [current at first contact and release are at its [the *valana*'s] tip like Sines. The long line between the tips of the *valanas* is oblique. The mean latitude is [given] from the center according to the quarters. In whatever manner the center of the disc of the eclipsing body is at the [three] marks of the latitudes at [respectively] first contact, mid-eclipse, and release, precisely in that manner the rule regarding the directions is to be considered.

Jñānarāja here explains how to draw the eclipse diagram. The directions are not entirely clear.

~ CONCLUDING VERSE ~

(40) [Thus] ends the section on lunar eclipses in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

Chapter 8

grahagaṇitādhyaṃya section 6

sūryagrahaṇādhikāra

Solar eclipses

~ THE EFFECT OF PARALLAX DESCRIBED ~

(1) Two men, one on the surface of the Earth, the other at its center, do not see the Sun being covered by the Moon at the same time. In the case of the man at the center of the Earth, the Moon reaches his line of sight towards the Sun precisely at the time of conjunction of the Sun and the Moon; it is not so in the case of the man on the surface.

Parallax is the phenomenon that a heavenly body (in our context only the planets), when viewed from the center of the Earth (we will have to postulate an imaginary “observer” there, as Jñānarāja does), is not seen at the same position with respect to the fixed stars as when it is viewed from a position on the surface of the Earth. This is illustrated in Figure 8.1, where the Sun, S , and the Moon, M , are observed from the location A on the surface of the Earth as well as from the center of the Earth, C . Each luminary is seen differently with respect to the fixed stars.

The parallax of a planet is the angle between the two lines formed by connecting the planet with, respectively, the center of the Earth and the given location on the surface of the Earth. In our example, the parallax of the Sun is the angle ASC and the parallax of the Moon is the angle AMC . As can be readily seen in the figure, the closer a planet is to the Earth, the greater its parallax; the parallax of the Moon is significant, while that of the Sun is minor (the magnitude of the parallax also depends on the position of the planet with respect to the zenith of the observer).

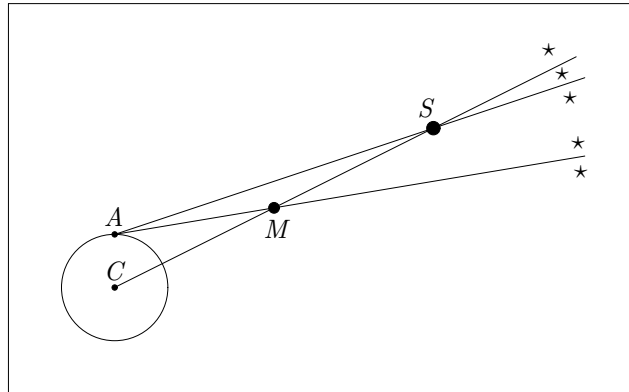


Figure 8.1: Parallax of the Sun and the Moon

When computing a lunar eclipse, it is not necessary to take parallax into account. The reason for this is that the effect of parallax is the same for the Moon and the shadow of the Earth, because they are seen at the same distance from the Earth. However, since the Sun and the Moon are at different distances from the Earth, the effect of parallax changes their positions not only with respect to the fixed stars, but also with respect to each other. As can be seen in Figure 8.1, for an observer at C , the Moon is seen eclipsing the Sun, whereas for an observer at A , at the same moment, no eclipse is seen. Parallax must therefore be taken into account in order to accurately compute a solar eclipse for a given locality. Note that the appearance of the Sun and the Moon as seen at C is not the same as that seen from most positions on the surface; if an observer is located at the point where the line CM intersects the surface of the Earth, he will of course see what the “observer” at C sees.

When it comes to the role of parallax in computing a solar eclipse, what we are interested in is the combined effect of parallax on the Sun and the Moon: in other words, how the effect of parallax changes the positions of the two luminaries with respect to each other. We will call this the combined parallax of the Sun and the Moon, or simply the combined parallax. On Figure 8.1, the combined parallax is the angle MAS , which, seen from A , is the angular distance between the Sun and the Moon measured against the backdrop of the fixed stars. It is easy to see that this angle is the difference of the angles AMC and ASC :

$$\begin{aligned}
 \angle MAS &= 180^\circ - \angle AMS - \angle ASC \\
 &= 180^\circ - (180^\circ - \angle AMC) - \angle ASC \\
 &= \angle AMC - \angle ASC.
 \end{aligned} \tag{8.1}$$

So, the combined parallax of the Sun and the Moon is the parallax of the Moon diminished by the parallax of the Sun.

Since the basic theory and computations of a solar eclipse are the same as those of a lunar eclipse, this chapter of the *Siddhāntasundara* is devoted to an exposition of parallax. In addition to its use in computing solar eclipses, the Indian tradition also uses parallax in computing conjunction

of planets.¹

~ LONGITUDINAL AND LATITUDINAL PARALLAX DEFINED ~

(2^{a-b}) **The longitudinal parallax is the distance, [measured] on the ecliptic, between the lines [of sight of the two observers]. The latitudinal parallax is [measured on a great circle situated] north-south [of the ecliptic, i.e., perpendicular to it].**

The effect of parallax is to make a planet appear closer to the horizon than it would be if viewed from the center of the Earth. More specifically, the effect pushes a planet downwards towards the horizon along a great circle through the local zenith. This can be deduced from Figure 8.1, where it is seen that the two lines of sight, AS and CS , both fall in the plane containing the center of the Earth (C), the given location on the surface of the Earth (A), the zenith corresponding to that location, and the Sun (S). In other words, seen from A , the position of the Sun and the position of the Sun under parallax fall on the same great circle through the zenith.

Consider Figure 8.2. The circle $ESWN$ is the horizon with the cardinal directions marked. The line NS is the meridian, and the center of the circle, Z , is the zenith. The arc LVB is the ecliptic. The two intersections of the ecliptic and the horizon, L and B , are, respectively, the ascendant and the descendant. The intersection of the ecliptic and the meridian, M , is called the meridian ecliptic point.² Let P be the pole of the ecliptic, and let the intersection of the ecliptic and the great circle through Z and P be V . This point is called the nonagesimal. It is the highest point of the ecliptic above the horizon, being 90° from both the ascendant and the descendant. Let further S' be the position of the Sun on the ecliptic and S'' the Sun under parallax (in other words, the angular distance $S'S''$ is the parallax of the Sun). Since the effect of parallax is to shift the position of the Sun downwards towards the horizon along a great circle through the zenith, the points Z , S' , and S'' are on the same straight line. Finally, let the arcs PS' and PS'' be parts of great circles through P . The intersection of the latter great circle and the ecliptic is called A .

The Indian astronomers separate parallax into two components. One component, called longitudinal parallax (*lambana*), is measured along the ecliptic, and the other, called latitudinal parallax (*nati*), is measured on a perpendicular to the ecliptic. The actual parallax, which is a combination of the two, will here be referred to as the total parallax.³ On Figure 8.2, $S'S''$ is the total parallax, $S'A$ the longitudinal parallax, and $S''A$ the latitudinal parallax. In the following, longitudinal parallax will be denoted by π_λ , latitudinal parallax by π_β , and the total parallax by π_t .

¹See, for example, *Siddhāntaśiromaṇi*, *Grahagaṇitādhyāya*, *Grahayutyadhikāra*, 7.

²This point is well-known in western astrology, where it is known as midheaven.

³Note that there is no Sanskrit term for the total parallax, only the terms for longitudinal and latitudinal parallax.

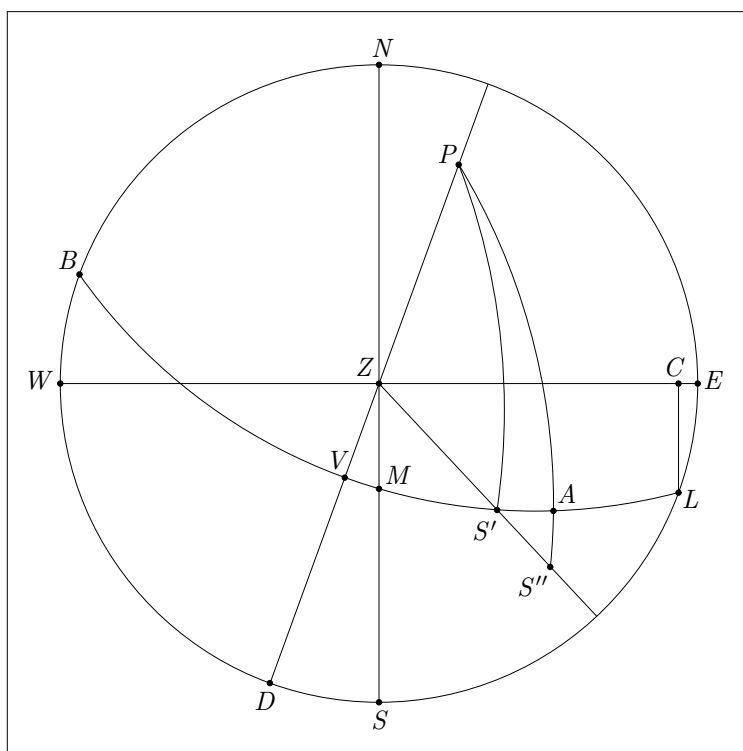


Figure 8.2: Projection used in computing parallax

(2^{c-d}) When [the longitude of] the Sun is equal to [that of] the meridian ecliptic point, there is no longitudinal parallax. When the Sun is at the midpoint of the prime vertical, there is neither of the two [parallaxes, i.e., neither longitudinal nor latitudinal parallax].

In this verse, Jñānarāja explains the conditions under which there either will be no longitudinal parallax or no parallax at all. According to him, the Sun has no longitudinal parallax when it is at the meridian ecliptic point, and it has no parallax at all when it is at the midpoint of the prime vertical.

The prime vertical is the great circle through the zenith and the east and west points. On Figure 8.2, it is the line *EZW*. Its midpoint is the zenith. In other words, if the Sun is at the midpoint of the prime vertical, it is at the zenith (if this is the case, the prime vertical and the ecliptic coincide). The second statement is therefore equivalent to saying that there is no parallax when the Sun is at the zenith. This is a true statement. If the Sun is at the zenith, the line of sight towards the Sun of an observer at the given location coincides with that of an observer at the center of the Earth, so that the Sun will have the same position with respect to the fixed stars for both of them.

The statement is, of course, true for any planet, not just the Sun. A planet located at the zenith has no parallax. Furthermore, it is easy to see that the planet's parallax increases as it gets closer to the horizon. On the horizon, a planet attains its greatest parallax.

Let us now consider the first statement and investigate under which conditions there is no longitudinal parallax. It is clear that the longitudinal parallax is nil if and only if the total parallax is perpendicular to the ecliptic. Otherwise, the total parallax would have a component along the ecliptic. Since the effect of parallax is that a planet is pushed down towards the horizon along a great circle through the zenith, this occurs only when this great circle is perpendicular to the ecliptic. This, in turn, occurs precisely when the Sun is at the nonagesimal. Since the nonagesimal and the meridian ecliptic point are distinct,⁴ Jñānarāja's first statement is incorrect.

It is unlikely that Jñānarāja is using a Sanskrit term normally used for the meridian ecliptic point (*madhyavilagna* in this case) to indicate the nonagesimal, for a comparison of verse 8^{b-d} with verse 9^c–10^b shows that he is aware of the distinction. Rather, the issue is that different texts give different accounts of when there is no longitudinal parallax. Some texts, like the *Brāhmasphuṭasiddhānta*⁵ and the *Siddhāntaśiromaṇi*⁶ state that it happens when the Sun is at the nonagesimal, while others, like the *Sūryasiddhānta*,⁷ state that it happens when the Sun is at the meridian ecliptic

⁴It may happen that they coincide at a given point in time, but this is the exception; generally, the two points are different.

⁵*Brāhmasphuṭasiddhānta* 5.2.

⁶*Siddhāntaśiromaṇi*, *Grahagaṇitādhyaṃya*, *Sūryagrahaṇādhikāra*, 2.

⁷*Sūryasiddhānta* 5.1; see the note in [9 . 162–164].

point. Jñānarāja's statement, therefore, is not to be taken as one that he mathematically derived or observationally verified; he is merely following a tradition.

The *Sūryasiddhānta* seems to be the main source that Jñānarāja followed when writing his chapter on solar eclipses. He adds demonstrations, but follows the general structure of the *Sūryasiddhānta*'s chapter on solar eclipses, and gives the same formulas as in that text.

~ GREATEST LONGITUDINAL PARALLAX ~

(3) **If there is no amount of degrees produced from the meridian ecliptic point, [then] the longitudinal parallax [of a planet] is measured by 4 *ghaṭikās* when it rises. That [value of 4 *ghaṭikās*] has been computed at the given time [for the rising of a planet] as well as at Sunrise [in the case of the Sun] by the wise sages using a variety of proportions.**

The meaning of the first line of the verse, *cen madhyalagnajanitāmśamiter abhāvaḥ*—literally, “If there is nonexistence of the amount of degrees produced from the meridian ecliptic point”—is not wholly clear. It is reasonable, though, to take it to mean that there are no degrees separating the meridian ecliptic point and the zenith, i.e., that the two points coincide. If taken in this way, the statement makes sense. When the meridian ecliptic point and the zenith coincide, the ecliptic, passing through the zenith, is perpendicular to the local horizon, and the total parallax, of the Sun or another planet, therefore equals the longitudinal parallax. Since parallax is greatest on the horizon, the longitudinal parallax reaches its maximum at the time of the rising or setting of the planet. In the Indian astronomical tradition, this maximum is given as 4 *ghaṭikās*, the value given by Jñānarāja in the verse.

The verse is here taken as a general statement that for any planet, the greatest longitudinal parallax is 4 *ghaṭikās*, which, as we shall see below, holds true. Whether Jñānarāja intended it this way, or if he is only talking about the Sun (as he did in the previous verse), is not clear. Taking it as I do, however, is the only way that I can make sense of *samaye 'bhimate*, “at a given time.” If he only deals with the Sun, the required time for the greatest longitudinal parallax would be Sunrise, already mentioned, or Sunset. Of course what Jñānarāja is ultimately interested in here is not the longitudinal parallax of a given planet, but rather the combined longitudinal parallax of the Sun and the Moon.

Now, why, when parallax is an angular distance, is it here expressed in terms of a unit of time, the *ghaṭikā*? The idea is to express parallax not as the angular distance described earlier, but as the amount of time that it takes the planet in question to traverse that angular distance. In other words, what we are seeking is the amount of time that it takes the Sun, or another planet, to traverse the angular distance corresponding to its greatest parallax. Note that in the Indian astronomical system, it is only the longitudinal parallax that is expressed as time, not the latitudinal parallax. The reason for this is that the longitudinal parallax is used to find the time of the apparent conjunction of the

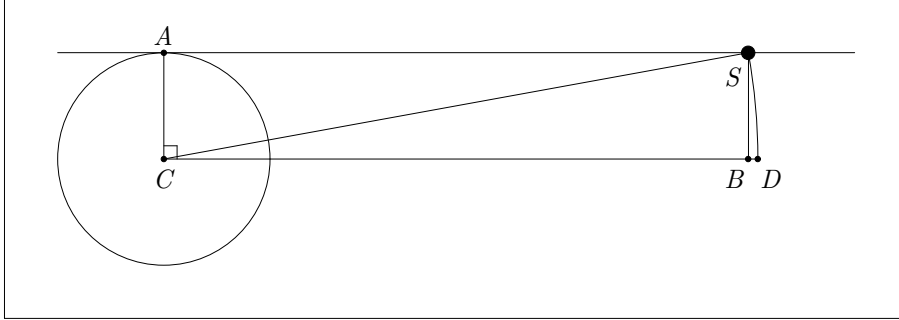


Figure 8.3: Greatest parallax of the Sun

Sun and the Moon, whereas the latitudinal parallax is used to correct the lunar latitude. In the following, π_λ will be used for both longitudinal parallax as an angular distance and as a measure of time; the context makes it clear which is intended.

On Figure 8.3, the Sun is on the horizon of the location A . In other words, observed from A , it has its greatest parallax. It can be seen that in this situation, the parallax of the Sun, i.e., the angular distance ASC , marks off a section of the Sun's orbit, namely the arc SD . Given the great distance between the Earth and the Sun, the length of this arc is roughly equal to the linear distance between S and B . This distance is equal to the radius of the Earth. One can therefore say that the greatest parallax of a planet is the radius of the Earth at the distance of the planet. In the *Siddhāntasundara*, the radius of the Earth, which we will denote by $r_\oplus$, is 800 *yojanas* (see 2.3.8 and commentary including fn. 7 on p. 206).

It is held in the Indian tradition that “every planet travels the same absolute distance in the same interval of time.”⁸ According to Jñānarāja, the number of *yojanas* traversed by each planet during a *mahāyuga* is 18,712,080,864,000.⁹ To find the number of *yojanas* traversed by each planet during a civil day, we divide this by the number of civil days in a *mahāyuga*,¹⁰ which gives¹¹

$$\frac{18,712,080,864,000}{1,577,917,828} = 11,858 \frac{282,814,894}{394,479,457}. \quad (8.2)$$

If the radius of the Earth is divided by this number and then expanded as a continued fraction, we get

$$\frac{800}{11,858 \frac{282,814,894}{394,479,457}} = \frac{1}{14 + \frac{1}{1 + \frac{69,666,585}{324,812,872}}} \approx \frac{1}{15}. \quad (8.3)$$

It thus takes a planet roughly one-fifteenth of a civil day to traverse the angular distance corresponding to its greatest parallax. In other words, the greatest parallax of a planet is roughly a fifteenth

⁸See [66 . 83] The word “planet” here includes the luminaries, as is our convention.

⁹See 1.1.74.

¹⁰See 2.1.15.

¹¹Prthūdakasvāmin, in his commentary on *Brāhmasphuṭasiddhānta* 21.12, gives, using Brahmagupta's parameters, the number of *yojanas* traversed by each planet during a civil day as $11,858 \frac{1,135,935,900,000}{1,577,915,450,000}$.

part of its mean velocity. Note that using the approximation $\frac{1}{15}$ is equivalent to assuming that each planet traverses 12,000 *yojanas* per civil day.

Using this result, we find the Moon's greatest parallax to be $\frac{790'35''}{15} = 52'42''$, and the Sun's to be $\frac{59'8''}{15} = 3'57''$. For future reference, let us note that a more accurate computation, in which we do not use the approximation $\frac{1}{15}$, yields the Moon's greatest parallax as $53'20''$,¹² and the Sun's as $3'59''$.¹³

Now, it is clear that the greatest parallax measured in time, as explained above, is the same for all the planets, as they each travel the same distance, i.e., one Earth radius. We therefore need only compute it for one planet. Since the mean velocity of the Moon $\bar{v}_{\zeta}$ is $790'35''$ per civil day, it takes the mean Moon 4;0 *ghaṭikās* to traverse $52'42''$ and 4;3 *ghaṭikās* to traverse $53'20''$. In both cases, roughly 4 *ghaṭikās*, as stated in the verse.

In the last half of the verse, Jñānarāja says that the value of 4 *ghaṭikās* was computed by the sages using a variety of proportions. In the next two verses, he will give a demonstration of how the greatest combined longitudinal parallax of the Sun and the Moon can be found, one that he presumably means to attribute to the before-mentioned sages.

One manuscript¹⁴ adds the number 14 after the word *munīndraiḥ*, “by the great sages,” indicating that the word was possibly understood by some as a number according to the *bhūtaśāṅkhyā* system (the correct value, however, would be 147, not 14). This, however, makes little sense.

~ TO FIND THE GREATEST COMBINED LONGITUDINAL PARALLAX ~

(4–5) **At the time of conjunction, when the Sun is on the eastern horizon for [an observer] situated at the center of the Earth, the upright [of a right-angled triangle] is the radius of the Earth [800 *yojanas*], the leg is the distance of the Sun [from the Earth] in *yojanas*, and the hypotenuse is the distance between our [location] and the Sun.**

Now, [if] the leg [of a right-angled triangle similar to the one just given] is the difference of the distances of the Sun and the Moon [from the Earth] in *yojanas*, what is the upright? It is the [combined] longitudinal parallax in *yojanas*.

[Let this combined longitudinal parallax be] multiplied by the radius

¹²Since there are 15 *yojanas* per minute of arc in the Moon's orbit (see verse 5.8), the Moon's greatest parallax is $\frac{800}{15} = 53'20''$.

¹³It may be there, but I have not yet located a passage in the *Siddhāntasundara* that states the number of *yojanas* in the orbit of the Sun. However, the value of $3'59''$ for the greatest parallax of the Sun can be deduced from the distance between the Earth and the Sun, which is given as 689,377 *yojanas* in 1.1.67. The same result is arrived at if the *saurapaṣa*'s value of the number of *yojanas* in the orbit of the Sun (given in [71 . 609]), i.e., 4,331,500, is used.

¹⁴V₅.

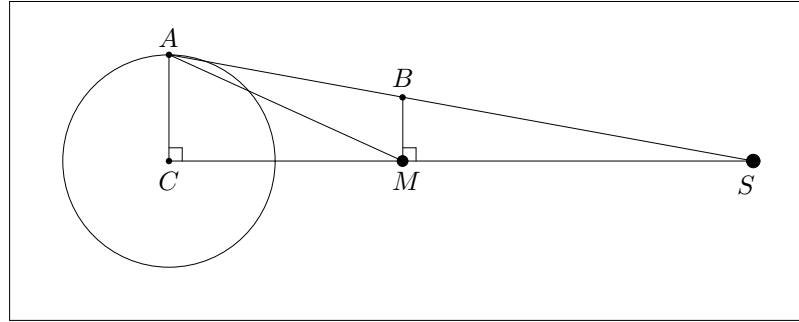


Figure 8.4: Jñānarāja's figure to find the greatest combined parallax

and divided by the distance of the Moon [from the Earth]. [The result is 48;45.]

[When] 48;45 minutes of arc [are] multiplied by 60 and divided by the difference of the [mean] velocities [of the Sun and the Moon, the result] is 4 *ghaṭikās*. [This] is the mean longitudinal parallax at rising and setting.

In these two verses, Jñānarāja demonstrates how the value of 4 *ghaṭikās* for the greatest combined longitudinal parallax can be found.

Consider Figure 8.4, which depicts the scenario described in the verses. In the figure, C is the center of the Earth and S the position of the Sun. Since the verse states that the Sun is on the horizon for an imagined “observer” at the Earth’s center, we take the line CS to be his “horizon”. It is further the time of conjunction, so the Moon, M , is found on this line (we are not taking lunar latitude into account; during an eclipse it is not of great magnitude anyway). Let further A be “our” location mentioned in the verse. Given the geometrical construction that Jñānarāja has in mind, the line CA has to be perpendicular on the line CS .

The triangle CAS has as its upright the radius of the Earth, as its leg the geocentric distance of the Sun, and as its hypotenuse the distance between the location A and the Sun. This is the triangle described by Jñānarāja in the verse.

Now, let B on the line AS be chosen so that the line BM is perpendicular on the line CS . Taking into account the magnitude of the Moon’s distance from the Earth compared to the radius of the Earth, we note that $|BM|$ is approximately the greatest combined parallax of the Sun and the Moon (the angle MAS in Figure 8.4) measured in *yojanas* at the Moon’s distance from the Earth. Our first step is to determine the length of BM .

Let $D_{\odot}$ denote the distance of the Sun from the Earth (the length CS in the figure), and $D_{\text{☾}}$ the distance of the Moon from the Earth (the length CM in the figure). The triangles CAS and MBS are similar, and hence

$$|BM| = \frac{|MS| \times |AC|}{|CS|} = \frac{(|CS| - |CM|) \times |AC|}{|CS|} = \frac{(D_{\odot} - D_{\text{☾}}) \times r_{\oplus}}{D_{\odot}}. \quad (8.4)$$

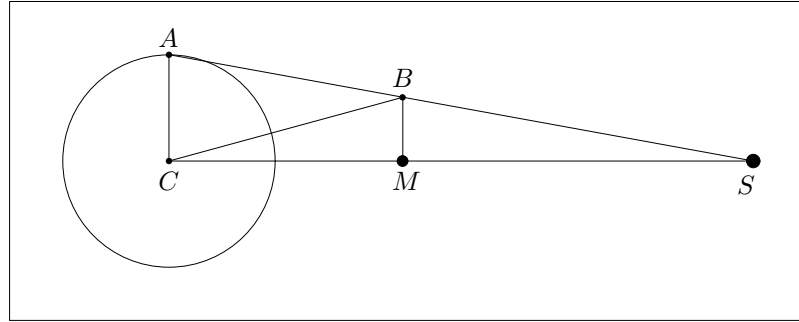


Figure 8.5: The greatest combined parallax as a sine

Since the radius of the Earth is 800 *yojanas*, the distance of the Sun from the Earth is 689,377 *yojanas*,¹⁵ and the distance of the Moon from the Earth is 51,566 *yojanas*,¹⁶ we find that the length of BM equals 740;10 *yojanas*.

Now, $|BM|$ is approximately the sine of the angle BCM with respect to a circle of radius D_{ζ} (see Figure 8.5). By multiplying $|BM|$ by R and dividing it by D_{ζ} , as Jñānarāja instructs us to do, we transform it into the Sine (i.e., a sine with respect to the radius R). The result of this operation is

$$\frac{740;10}{51,566} \times 3,438 = 49;21, \quad (8.5)$$

which Jñānarāja, however, gives as 48;45.

Since 49;21 is a small number (compared to $R = 3,438$), its Sine is approximately equal to 49'21". In other words, the Sine of the angle BCM , which is the greatest combined parallax of the Sun and the Moon, is 49'21", or, if we use Jñānarāja's number, 48'45".

That Jñānarāja gets 48;45 instead of 49;21 is not surprising. We know from the notes to verse 1 that the greatest combined parallax of the Sun and the Moon is equal to the greatest parallax of the Moon diminished by the greatest parallax of the Sun. In the notes to verse 3, we found the greatest parallax of the Moon to be 52'42" and that of the Sun to be 3'57". The difference of these is 52'42" – 3'57" = 48'45", the result given by Jñānarāja. However, using the more accurate values computed subsequently, we get 53'20" – 3'59" = 49'21", the result we arrived at. That Jñānarāja gives 48'45" in the verse rather than 49'21" seems to indicate that he did not himself follow the computations he describes in the verses, but rather inserted an already known result.

Finally, since the velocity of the Sun and the Moon with respect to each other is the difference of their respective velocities, we can convert the greatest combined parallax of the Sun and the Moon into *ghaṭikās* by multiplying it by 60 and dividing it by the difference of the mean velocities of the

¹⁵See 1.1.67.

¹⁶See 1.1.66.

Moon and the Sun, $\bar{v}_{\zeta}$ and $\bar{v}_{\odot}$:¹⁷

$$60 \times \frac{49'21''}{\bar{v}_{\zeta} - \bar{v}_{\odot}} = \frac{2961}{790'35'' - 59'8''} = 4;3. \quad (8.6)$$

In other words, a body moving with the combined motion of the Sun and the Moon will take 4;3 *ghaṭikās* to traverse the angular distance 49;21. Using Jñānarāja's value 48'45'', we get 4;0 *ghaṭikās*: in both cases a value close to 4 *ghaṭikās*, as stated in the verse.

~ TO FIND THE SINE OF THE RISING AMPLITUDE OF THE ASCENDANT ~

(6^{a-c}) **[When] the Sine of 24° is multiplied by the Sine of [the longitude of] the precession-corrected ascendant and divided by the Sine of the local co-latitude, the result is the Sine of the rising amplitude of the ascendant.**

In this and the following verses, Jñānarāja gives the formulas for computing a number of quantities that will be used to compute the longitudinal and latitudinal parallax, namely the Sine of the rising amplitude of the ascendant, the Sine of the zenith distance of the nonagesimal, and the Sine of the altitude of the nonagesimal.

The rising amplitude of the ascendant (*udayaḥjyā*), denoted here by η_L , is the line CL on Figure 8.2. The 24° mentioned is the obliquity of the ecliptic, ε . Furthermore, the declination of the ascendant is denoted by δ_L , the longitude of the ascendant by λ_L , and the longitude of the ascendant corrected for precession by λ_L^* . The latitude is denoted by ϕ and the co-latitude by $\bar{\phi}$.

The third triangle in the list of similar triangles on p. 179 gives us that

$$\text{Sin}(\eta_L) = \frac{R \times \text{Sin}(\delta_L)}{\text{Sin}(\bar{\phi})}. \quad (8.7)$$

If this is combined with the regular formula for determining the declination of the ascendant (using the usual formula for determining the declination of a point on the ecliptic given its longitude),

$$\text{Sin}(\delta_L) = \frac{\text{Sin}(\varepsilon) \times \text{Sin}(\lambda_L^*)}{R}, \quad (8.8)$$

we get

$$\text{Sin}(\eta_L) = \frac{\text{Sin}(\varepsilon) \times \text{Sin}(\lambda_L^*)}{\text{Sin}(\bar{\phi})}, \quad (8.9)$$

which is the formula given in the verse.

In verse 13^{a-b}, Jñānarāja gives a demonstration of the formula by noting that it is derived from the two proportions (8.7) and (8.8).

~ TO FIND THE SINE OF THE ZENITH DISTANCE OF THE MERIDIAN ECLIPTIC POINT ~

(6^{c-d}) **The Sine of the zenith distance of the meridian ecliptic point is computed by means of the combination of the degrees of the [local] latitude**

¹⁷The mean velocities are measured in minutes of arc per civil day; the “60” is to convert from civil days to *ghaṭikās*.

and the degrees of the declination of the meridian ecliptic point.

By “combination” (*samskṛti*) is meant that the two quantities are either added to or subtracted from each other according to whether the meridian ecliptic point is below or above the celestial equator. The zenith distance and the declination of the meridian ecliptic point (*natajyā*) are here denoted by z_M and δ_M . For the formula indicated here,

$$\text{Sin}(z_M) = \text{Sin}(\phi \pm \delta_M), \quad (8.10)$$

compare 2.3.38.

~ TO FIND THE SINE OF THE ZENITH DISTANCE OF THE NONAGESIMAL ~

(7^a-d) [Let] that [Sine of the zenith distance of the meridian ecliptic point be] multiplied by the Sine of the rising amplitude of the ascendant and divided by the radius. [Take] the difference of the square of the result and the square of the Sine of the zenith distance of the meridian ecliptic point. The square root of that [difference] is the Sine of the zenith distance of the nonagesimal.

The zenith distance of the nonagesimal (*dr̥ṣṭikṣepa* or *dr̥kkṣepa*) is denoted by z_V .

The formula given in the verse is

$$\text{Sin}(z_V) = \sqrt{(\text{Sin}(z_M))^2 - \left(\frac{\text{Sin}(z_M) \times \text{Sin}(\eta_L)}{R} \right)^2}. \quad (8.11)$$

Jñānarāja gives a demonstration of it in verse 13^c-14^b, and a discussion of the formula is found in the commentary there.

~ TO FIND THE SINE OF THE ALTITUDE OF THE NONAGESIMAL ~

(7^d-8^a) The square root of the difference of that [Sine of the zenith distance of the nonagesimal] and the square of the radius is the Sine of the altitude of the nonagesimal.

The Sanskrit phrase used by Jñānarāja to designate the Sine of the altitude of the nonagesimal is *dr̥ggatisaṅjñāsaṅkur*, “the altitude called the *dr̥ggati*.” This usage of the term *dr̥ggati* is consistent with that of the *Sūryasiddhānta*,¹⁸ but it is noteworthy that it is used differently in other texts. The *Śiṣyadhīvr̥ddhidatantra* and the *Vaṭeśvarasiddhānta*,¹⁹ for example, use the term to designate the

¹⁸*Sūryasiddhānta* 5.6.

¹⁹*Śiṣyadhīvr̥ddhidatantra* 6.6. *Vaṭeśvarasiddhānta* 5.1.9.

square root of the difference of the squares of the Sine of the zenith distance of the nonagesimal and the Sine of the zenith distance of the Sun. This is approximately $|VS'|$ on Figure 8.2, if the triangle ZVS' is considered planar and right-angled. It is perhaps to avoid confusion over these different usages of the term *ḍṛggati* that Jñānarāja specifically says that it is an altitude (*śaṅku*). Bhāskara II does not use the term *ḍṛggati*; he does, however, use the term *ḍṛṇināti* to designate what Lalla and Vateśvara call *ḍṛggati*.

Let α_V and z_V designate the altitude and the zenith distance of the nonagesimal, respectively. The formula given in the verse,

$$\text{Sin}(\alpha_V) = \sqrt{R^2 - (\text{Sin}(z_V))^2}, \quad (8.12)$$

is straightforward. Jñānarāja gives a derivation of it in verse 14^b.

~ TO FIND THE LONGITUDINAL PARALLAX ~

(8^{b-d}) **The square of half the radius divided by the Sine of [the] altitude [of the nonagesimal] is [called] the divisor. The quotient obtained from the division of the Sine of the difference between [the longitudes of] the meridian ecliptic point and the Sun by the divisor is the *ghaṭikās* of the longitudinal parallax.**

In the verse, Jñānarāja merely says *nara*, “Sine of altitude”, by which he must mean the Sine of the altitude of the nonagesimal. A formula for the Sine of this altitude was just given, and its appearance in the formula is consistent with the derivation of the formula in verse 14^c–15 as well as with the corresponding formula in the *Sūryasiddhānta*.²⁰ An alternative would be the Sine of the altitude of the meridian ecliptic point, which is used in the corresponding formula in the *Śiṣyadhīvr̥ddhidatantra*.²¹ Additionally, it is worth noting that some manuscripts²² gloss the word *nara* as 12, indicating an incorrect interpretation of the word as a gnomon.

Let $\lambda_{\odot}$, λ_M , and λ_V denote the longitudes of the Sun, the meridian ecliptic point, and the nonagesimal, respectively. The formula of the verse,

$$\pi_{\lambda} = \frac{\text{Sin}(\lambda_M - \lambda_{\odot})}{\frac{(\frac{R}{2})^2}{\text{Sin}(\alpha_V)}} = \frac{4 \times \text{Sin}(\lambda_M - \lambda_{\odot}) \times \text{Sin}(\alpha_V)}{R^2}, \quad (8.13)$$

is derived by Jñānarāja from two proportions in verse 14^c–15, and so a discussion of it will be postponed until this point in the text.

As explained earlier, we would expect that the longitudinal parallax vanishes at the nonagesimal rather than at the meridian ecliptic point, which would require λ_V instead of λ_M in the formula

²⁰*Sūryasiddhānta* 5.7–8.

²¹*Śiṣyadhīvr̥ddhidatantra* 6.8.

²²R₁ and R₂.

(as in the formula in verse 10^{a-b}). The formula given here is the same as that found in the *Sūryasiddhānta*.²³

~ TO APPLY LONGITUDINAL PARALLAX ~

(9^{a-b}) **This longitudinal parallax is to be applied positively or negatively to [the time of] conjunction according to whether [the longitude of] the Sun is less than or greater than [that of] the meridian ecliptic point.**

Here, again, we would expect the nonagesimal where the meridian ecliptic point is mentioned. As before, Jñānarāja follows the *Sūryasiddhānta* in this respect.²⁴

When, at true conjunction, the Sun and the Moon are to the west of the nonagesimal (this happens when the longitude of the Sun is less than that of the nonagesimal), the apparent position of the Moon is further to the west on the ecliptic than the apparent position of the Sun. This means that the apparent conjunction has not yet occurred. Therefore, the longitudinal parallax, measured as time, is to be added to the time of conjunction.

Similarly, if the Sun and the Moon are to the east of the nonagesimal, the longitudinal parallax, measured as time, is to be subtracted from the time of conjunction.

To illustrate this, see Figure 8.2. When the Sun and the Moon are east of V , the Moon appears farther east than the Sun. That is because if the Sun and the Moon were together at S' , and the Sun is apparently displaced from S' to S'' along line ZS' due to parallax, then the larger parallax of the Moon would displace it even further toward the horizon along the same line. This being so, its longitudinal parallax would also be larger, so it would appear east of the Sun. In other words, the apparent eclipse would already have occurred, so the parallax time would be subtracted from the time of conjunction.

~ AN ALTERNATIVE FORMULA FOR THE LONGITUDINAL PARALLAX ~

(9^{c-10^b}) **Or, [let] the Sine of the difference between the [longitudes of] the nonagesimal and the Sun [be] multiplied by 4 and divided by the radius. [The result is called] the small longitudinal parallax. Some people say that that [small longitudinal parallax] multiplied by the Sine of the altitude of the nonagesimal and divided by the radius is the accurate [longitudinal parallax].**

²³*Sūryasiddhānta* 5.7–8.

²⁴See *Sūryasiddhānta* 5.9.

The small longitudinal parallax given first,

$$\pi_\lambda = \frac{4 \times \text{Sin}(\lambda_V - \lambda_\odot)}{R} \quad (8.14)$$

corresponds to a situation where the nonagesimal and the zenith coincide. In this case, the total parallax can be found by the proportion

$$\frac{\pi_t}{\pi_0} = \frac{\text{Sin}(\lambda_V - \lambda_\odot)}{R}, \quad (8.15)$$

where π_0 is the greatest parallax. Since in this situation, the ecliptic is perpendicular to the horizon, $\pi_\lambda = \pi_t$. Using this and π_0 being 4 *ghaṭikās*, we get Jñānarāja's formula for the small longitudinal parallax.²⁵

The next step is to extend the formula to the situation where the nonagesimal and the zenith do not coincide. This gives us the formula

$$\pi_\lambda = \frac{4 \times \text{Sin}(\lambda_V - \lambda_\odot) \times \text{Sin}(\alpha_V)}{R^2}. \quad (8.16)$$

With the exception that λ_M is replaced by λ_V , the formula is identical to that of verse 8^{b-d}. For its derivation, see verse 14^{c-15} (where Jñānarāja derives the formula of verse 8^{b-d}) and commentary.

The formula is given in the *Brāhmasphuṭasiddhānta*²⁶ and the *Siddhāntaśiromaṇi*,²⁷ so the “some people” of the verse presumably refers to Brahmagupta, Bhāskara II, and their followers.

~ TO FIND THE LATITUDINAL PARALLAX ~

(10^{c-d}) **The latitudinal parallax is [computed] from the Sine of the ecliptic zenith distance divided by 70. It is said that its direction is [the same as] that of the Sine of the zenith distance of the meridian ecliptic point. The lunar latitude is corrected by it.**

Jñānarāja now gives a formula for computing the latitudinal parallax. The same formula is found in the *Sūryasiddhānta*.²⁸

To derive the formula, we consider, as is nearly correct, that the latitudinal parallax can be found by the proportion

$$\frac{\pi_0}{R} = \frac{\pi_\beta}{\text{Sin}(z_V)}, \quad (8.17)$$

where π_0 again is the greatest parallax.

As noted under verse 3, latitudinal parallax is measured not as time, but as an angular distance. From what we found earlier, the greatest parallax of, say, the Sun is $\frac{1}{15} \times \bar{v}_\odot$. However, we are

²⁵The term *laghulambana*, “small longitudinal parallax,” denotes the longitudinal parallax at noon in the *Vaṭeśvara-siddhānta* (5.1.21).

²⁶*Brāhmasphuṭasiddhānta* 5.4.

²⁷*Siddhāntaśiromaṇi*, *Grahagaṇitādhyaṃya*, *Sūryagrahaṇādhikāra*, 4.

²⁸*Sūryasiddhānta* 5.11; see also *Sūryasiddhānta* 5.10.

interested in the combined latitudinal parallax of the Sun and the Moon, which is $\frac{1}{15} \times (\bar{v}_{\zeta} - \bar{v}_{\odot})$. If we insert this in formula (8.17), we get

$$\pi_{\beta} = \frac{\bar{v}_{\zeta} - \bar{v}_{\odot}}{15 \times R} \times \text{Sin}(z_V). \quad (8.18)$$

Since

$$\frac{\bar{v}_{\zeta} - \bar{v}_{\odot}}{15 \times R} \approx \frac{1}{70}, \quad (8.19)$$

we get the formula of the verse. Note that according to the formula, once we know the zenith distance of the nonagesimal, the latitudinal parallax is the same at any point of the ecliptic. This is roughly correct.²⁹

It is easy to see that the direction of the latitudinal parallax is the same as that of the Sine of the meridian ecliptic point. In other words, it is north when the meridian ecliptic point is north of the zenith, and south when it is south of the zenith.

The latitudinal parallax is used to correct the lunar latitude. After such a correction is made, we have the proper distance between the Sun and the Moon on a great circle perpendicular to the ecliptic, as seen from our location.

~ TO COMPUTE A SOLAR ECLIPSE ~

(11–12^b) [When] the time of true conjunction is repeatedly corrected by the longitudinal parallax [until it is] constant, [the result] is the [time of] apparent [conjunction]. The lunar latitude at that [time of apparent conjunction] is corrected by the latitudinal parallax. The amount of obscuration and the half-duration [of the eclipse] is [computed] from that [corrected lunar latitude]. The longitudinal parallax is to be computed [repeatedly] from the time of true conjunction increased or diminished by the half-duration. Separately, by means of the accurate [longitudinal parallax], [we get the time of] first contact and the time of release, respectively.

The first step in computing a solar eclipse is to find the time of apparent conjunction, i.e., the time when the Sun and the Moon are seen in conjunction at our location. This is done iteratively by Jñānarāja, using a method found in the *Sūryasiddhānta*³⁰ and the *Siddhāntaśiromaṇi*.³¹

The iterative process works as follows.³² Let the time of true conjunction be t_0 and the longitudinal parallax at that time π_1 . When t_0 is corrected by π_1 , we get a new time, say t_1 . The apparent

²⁹See Burgess' notes to *Sūryasiddhānta* 5.10 in [9.170–2].

³⁰*Sūryasiddhānta* 5.9.

³¹*Siddhāntaśiromaṇi*, *Grahagaṇitādhyāya*, *Sūryagrahaṇādhikāra*, 7.

³²The process is described in Bhāskara II's own commentary on *Siddhāntaśiromaṇi*, *Grahagaṇitādhyāya*, *Sūryagrahaṇādhikāra*, 7.

conjunction, however, does not take place at the time t_1 , because at that time, the longitudinal parallax will be different from π_1 . We therefore compute the longitudinal parallax for t_1 , getting, say, π_2 , and correct the time of true conjunction with this new value of the longitudinal parallax. This yields, say, the time t_2 . We now repeat this procedure until the times generated remain constant, say t_n (or, equivalently, until the longitudinal parallaxes generated remain constant, say π_n). This time is the time of the apparent conjunction.

After obtaining the time of apparent conjunction, we can compute the lunar latitude at that time. This latitude is then to be corrected by the latitudinal parallax.

Given the corrected lunar latitude, we can now, just as we did in the chapter on lunar eclipses, calculate the amount of obscuration of the eclipse, the half-duration of the eclipse, and so on.

From the half-duration we can further find the approximate times of first contact and release. This is done by subtracting and adding the half-duration to the time of apparent conjunction, just as is the case for lunar eclipses. This will not produce the correct times, and as was the case for a lunar eclipse, we need to repeat the procedure until the times are fixed. Needless to say, Jñānarāja is rather brief in this verse, apparently expecting the reader to already be familiar with the procedure.

Once we have the accurate times of first contact, mid-eclipse (i.e., the time of apparent conjunction), and release, we can proceed with the eclipse calculations as with a lunar eclipse.

Jñānarāja's text poses some problems at this point. Firstly, *sthiravilambanasamskṛto* is literally "corrected by the longitudinal parallax which is constant," but the meaning has to be "until it is constant," as indicated in the translation. Secondly, the end of verse 11 is problematic, and I am not sure that my choice of reading (*prthak sphuṭena*) is necessarily the best one.

~ COLORS OF THE ECLIPSED BODY ~

(12^{c-d}) [During a lunar eclipse,] the Moon is smoke-colored when [the obscuration of its disc] is small; black when its disc is half [obscured], and tawny when the obscuration is total. [During a solar eclipse, the obscured portion of] the Sun is always black.

Schemes giving the color of the Moon according to the phase of the lunar eclipse are common in Indian astronomical texts.³³ Some minor variations apart, the schemes agree with each other. Jñānarāja's scheme is unusual, though, in that it gives only three colors, whereas other texts give four.

In the case of a solar eclipse, the obscured portion of the Sun's disc is always considered black in the Indian tradition.

³³See, for example, *Āryabhaṭīya*, *Gola*, 46; *Brāhmasphuṭasiddhānta* 4.19; *Śiṣyadhīrvṛddhidatantra* 5.36; and *Siddhāntaśiromaṇi*, *Grahagaṇitādhyāya*, *Sūryagrahaṇādhikāra*, 36. An earlier scheme, in which the colors are assigned depending on "... the altitude of the eclipsed body, its relation to the ascendant or descendant, and its magnitude..." is found in the *Pañcasiddhāntikā* 6.9–10 (see [71 . 550]).

It is interesting that Jñānarāja gives the eclipse colors in this section, and not, as is usually the case, in the section on lunar eclipses.

~ DEMONSTRATION VERSES ~

Now [three] verses [giving] demonstrations.

Jñānarāja now gives three verses in which demonstrations of some of the formulas of the chapter are given. In all the manuscripts except one,³⁴ these three verses are given as part of the solar eclipse chapter.

~ DERIVATION OF THE RISING AMPLITUDE OF THE ASCENDANT ~

(13^{a-b}) **The rising amplitude [computed] from a combination [of] two proportions that [both] involve the Sine of the declination of the ascendant at the time of conjunction [of the Sun and the Moon] is called the rising amplitude of the ascendant.**

The two proportions involved in computing the rising amplitude of the ascendant are (see the list of similar triangles on p. 179)

$$\frac{\text{Sin}(\delta_L)}{\text{Sin}(\eta_L)} = \frac{\text{Sin}(\bar{\phi})}{R} \quad (8.20)$$

and

$$\frac{\text{Sin}(\delta_L)}{\text{Sin}(\lambda_L^*)} = \frac{\text{Sin}(\varepsilon)}{R}. \quad (8.21)$$

The Sine of the declination of the ascendant is found in both of them. See the commentary on verse 6^{a-c}.

~ DERIVATION OF THE ZENITH DISTANCE OF THE MERIDIAN ECLIPTIC POINT ~

(13^b) **The Sine of the zenith distance of the meridian ecliptic point is [found] from [the longitude of] the meridian ecliptic point.**

The term *ḍṛggyā* normally refers to the Sine of the zenith distance of the Sun.³⁵ However, this cannot be the case here, because we cannot generally determine the Sun's zenith distance from the

³⁴V₅, in which the concluding verse and the chapter colophon are given after verse 12, the three verses being appended afterwards.

³⁵See, for example, *Śiṣyadhīvr̥ddhidatantra* 6.6, *Vaṭeśvarasiddhānta* 5.1.5, and *Siddhāntaśiromaṇi*, *Graha-gaṇitādhyāya*, *Sūryagrahaṇādhikāra*, 5.

longitude of the meridian ecliptic point. Considering how the text progresses in the following, the term must refer to the Sine of the zenith distance of the meridian ecliptic point.

We can compute the declination of the meridian ecliptic point from its longitude, and, in turn, its zenith distance from its declination (see verse 6^{c-d}), so the statement in the verse is clear (although, perhaps, not very profound).

~ DERIVATION OF THE SINE OF THE ZENITH DISTANCE OF THE NONAGESIMAL ~

(13^c–14^b) **[If,] when the radius [is the hypotenuse of a right-angled triangle], the leg is measured by the rising amplitude, then what is [the leg of a similar triangle, when the hypotenuse is measured] by the Sine of the zenith distance of the meridian ecliptic point? The result is a leg [corresponding to an arc that is] extending east-west on the ecliptic.**

The upright [of the triangle whose leg we just found] is said to be the square root of the difference of the square of that [leg] and the square of the Sine of the zenith distance of the meridian ecliptic point. It is the zenith distance of the nonagesimal.

Consider Figure 8.6, where everything is as on Figure 8.2. Since the lines ZL and ZV are perpendicular to each other, the angle VZM equals the angle LZC . If we consider the triangle ZMV in the plane of the projection to be right-angled, its right angle being $\angle ZMV$ (one would expect that $\angle ZVM$ to be the right angle, but that is not how Jñānarāja takes it), it is similar to triangle ZCL . We thus have the proportion

$$\frac{|VM|}{|ZM|} = \frac{|LC|}{|ZL|}. \quad (8.22)$$

This is the proportion given by Jñānarāja in the verse, since ZL is the radius, LC the rising amplitude of the ascendant, and $|VM|$ approximately the leg corresponding to the arc VM on the ecliptic.

From the proportion we get

$$|VM| = \frac{|ZM| \times |LC|}{|ZL|} = \frac{\text{Sin}(z_M) \times \text{Sin}(\eta_L)}{R}. \quad (8.23)$$

Jñānarāja next finds the upright of triangle ZMV , i.e., the zenith distance of the nonagesimal. This is done using the Pythagorean theorem, which yields that

$$\begin{aligned} \text{Sin}(z_V) &= \text{Sin}(ZV) = |ZV| \\ &= \sqrt{|ZM|^2 - |VM|^2} \\ &= \sqrt{(\text{Sin}(z_M))^2 - \left(\frac{\text{Sin}(z_M) \times \text{Sin}(\eta_L)}{R} \right)^2}. \end{aligned} \quad (8.24)$$

Figure 8.6: Projection used in computing the Sine of the zenith distance of the nonagesimal

We have now demonstrated the formula given in verse 7^{a-d}.

~ DERIVATION OF THE SINE OF THE ALTITUDE OF THE NONAGESIMAL ~

(14^b) The hypotenuse corresponding to that [upright, i.e., the Sine of the zenith distance of the nonagesimal,] is the radius, and the leg corresponding to the two of them is the Sine of the altitude of the nonagesimal.

The formula, originally given in verse 7^d-8^a and now demonstrated,

$$\text{Sin}(\alpha_V) = \sqrt{R^2 - (\text{Sin}(z_V))^2}, \quad (8.25)$$

is straightforward.

Here, as in verses 7^d-8^a, Jñānarāja emphasizes that the *dr̥ggati* is an altitude (*śāṅku*).

~ DERIVATION OF THE LONGITUDINAL PARALLAX ~

(14^c-15) [If] the longitudinal parallax is 4 when the Sine of the difference of [the longitudes of] the meridian ecliptic point and the Sun is the radius, what is it in the case of a given [value of the Sine of the difference of the longitudes of the meridian ecliptic point and the Sun]? Then, if that [particular value of the longitudinal parallax is attained when] the Sine of the altitude of the nonagesimal is the radius, what [is it] in the case of a given [Sine of the altitude of the nonagesimal]?

In this pair of proportions, both divisors are the radius. Their product divided by 4 is furthermore [a quantity] equal to the square of the Sine of 30°. [That quantity] divided by the Sine of the altitude of the nonagesimal is called the divisor. The Sine of the difference of [the longitudes of] the ascendant and the Sun divided by that [divisor] is the accurate longitudinal parallax in *ghaṭikās* and so on.

Jñānarāja now shows how to derive the formula for the longitudinal parallax from two proportions.

If the longitudinal parallax is 4 (i.e., the greatest parallax, π_0) when the Sine of the difference of the longitudes of the meridian ecliptic point and the Sun is R , what is it for any given value of this Sine? Let it be π_1 . Now, if this is the value of the longitudinal parallax when the Sine of the

altitude of the nonagesimal is R (i.e., when Z and V coincide), what is it for any given value of this Sine? Let it be π_2 .

Written out as equations, the two proportions are

$$\frac{\text{Sin}(\lambda_M - \lambda_\odot)}{R} = \frac{\pi_1}{4} \quad (8.26)$$

and

$$\frac{\text{Sin}(\alpha_V)}{R} = \frac{\pi_2}{\pi_1}. \quad (8.27)$$

The first proportion corresponds to the situation where the ecliptic passes through the zenith, while the second takes the distance between the zenith and the nonagesimal into account. The second value of the longitudinal parallax, π_2 , is therefore the longitudinal parallax, π_λ , that we are seeking.

Combining the two proportions will yield a formula for the longitudinal parallax. Jñānarāja combines them as follows. The divisor of each proportion is R . Dividing their product by 4 (i.e., by π_0), we get $\frac{R^2}{4} = (\frac{R}{2})^2 = (\text{Sin}(30^\circ))^2$.³⁶ Let this quantity divided by the Sine of the altitude of the nonagesimal be called the divisor. Finally, the Sine of the difference of the longitudes of the meridian ecliptic point³⁷ and the Sun is divided by the divisor, yielding the formula

$$\pi_\lambda = \frac{\text{Sin}(\lambda_M - \lambda_\odot)}{\frac{(\text{Sin}(30^\circ))^2}{\text{Sin}(\alpha_V)}} = \frac{4 \times \text{Sin}(\lambda_M - \lambda_\odot) \times \text{Sin}(\alpha_V)}{R^2} \quad (8.28)$$

as the combination of the two proportions. It is precisely the formula of verse 8^{b-d}.

Bhāskara II, in his commentary on *Śiṣyadhīrvṛddhidatantra* 6.8, gives essentially the same demonstration. Following Lalla, he uses $\text{Sin}(\alpha_M)$ instead of $\text{Sin}(\alpha_V)$, and the two proportions are presented in the opposite order, but otherwise the demonstration proceeds exactly like Jñānarāja's.

~ CONCLUDING VERSE ~

(16) Thus [ends] the section on solar eclipses accompanied by demonstration in the beautiful and abundant *tantra* composed by Jñānarāja, the son of Nāganātha, which is the foundation of [any] library.

³⁶Note that the *Sūryasiddhānta* (5.7) also expresses the formula using $\text{Sin}(30^\circ)$.

³⁷Although the verse says “ascendant” (*lagna*), “meridian ecliptic point” (*madhyalagna*) is intended here.

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〈अथ गोलाध्याये भुवनकोशाधिकारः〉

भाले यस्य कलानिधिर्मधुमिलझृङ्गावली गण्डयोः
कण्ठे ऽहिर्विलसत्यलं पदयुगे गीर्वाणचेतोगणाः ।
ब्रह्मापि त्रिजगत्सिसृक्षुरभजन्निर्विघ्नसंसिद्धये
श्रीमन्मङ्गलमूर्तिमाद्यमलयं तं नौमि भक्तप्रियम् ॥ १ ॥

f. 9v M₁

5

यन्नामाक्षररश्मिभिस्तनुगतैश्चञ्चत्कलावान्भवे -
इक्तः स्वान्तनिशाकरो हततमास्तत्रोच्चरद्भिः क्रमात् ।
नत्वा तां भुवनेश्वरीमपि गुरुन्सिद्धान्तसत्सुन्दरं
सुज्ञानन्दकरं करोमि चतुरं ज्ञानाधिराजः स्फुटम् ॥ २ ॥

The *golādhyāya* opens श्रीगणेशाय नमः B₂V₂, श्रीमंगलमूर्तये गजाननाय नमः B₃R₃, अथ गोलाध्यायो लिख्यते M₁M₂, श्रीवरदसूक्तिर्जयति O, अथ गोलाध्यायपूर्वाद्ध R₁, श्रीगुरुभ्यो नमः V₅ the verse दिङ्मातृगसुतुंगपंचवदनं विश्वैकलंबोदरं चूडारत्नसहस्रभूधरमहाहारं सुनीलांबरं । स्वांतध्वांतहरं कलानिधिधरं कोटीनरुक्सुंदरं वाराहोपमवाहनं गणपतिं वंदे परं शंकरं (see 2.1.1) numbered 1 opens chapter M₁M₂ Verse 1 numbered 2 M₁M₂ 2 भाले] corrected from भोले to भाले B₂ कला] काला R₁ मधु] मिथु R₁ झृङ्गा] झृगा M₁, तभृङ्गा M₂, झृगा O 2-3 गण्डयोः कण्ठे] गंड[यो]यो कंठे B₂, कर्णयोष्कंठे R₁, गंडयोः कंडे V₅ 3 ऽहि] हिं M₁ त्यल] त्यम R₁ पद] पर R₁ गणाः] गुणाः R₁, गुणः V₅ 4 त्सिसृक्षु] त्सिसृक्षु R₁ रभजन्नि] रभज[x]न्नि B₂, रभवन्नि M₁, रभवं नि M₂, रभ(z)_{marg} नि V₅ सिद्धये] सिद्ध(ये)_{marg} B₂ 5 न्मङ्गल] न्मंग M₁ माद्य] साद्य R₁ मलयं] मलयं marked and the annotation नास्ति लयो यस्य अलयस्तं B₂, (ऽ)_{supl} मलयं B₃, ममथं R₁ Verse 2 numbered 3 M₁M₂ 6 यन्नामा] corrected from यन्नमा to यन्नामा V₅ क्षर] क्ष[x]र O श्मिभि] corrected to this from an illegible original reading O गतैश्च] गतैः किंचि V₅ त्कला] त्क[वनत्व]ला O न्भवे] न[सिद्धां]भवे O 7 इक्तः] इक्त B₂OR₃V₁V₅, इक्त M₂ स्वान्त] स्वांत[x] B₂, स्रांत M₂ करो] करा R₁ हत] ह[x]त B₂ चोच्च] चोब्ध M₁ रद्भिः] रभि(:)_{supl} B₃, रद्भिः? M₂, रभिः V₂ 8 श्वरीमपि] श्वरीमपि M₁ गुरुन्सि] गुरुत्सि B₃M₂, गुरुन्सि R₃, गुरुं सि V₅ सत्सु] (स)_{marg}त्सु B₂ 9 करं] om. V₅

यन्नारदाय गदितं चतुराननेन
 ज्ञानं ग्रहर्क्षगतिसंस्थितिरूपमग्यम् ।
 |शाकल्यसञ्ज्ञमुनिना निखिलं निबद्धं
 पद्यैस्तदेव विवृणोमि सवासनं स्वैः ॥ ३ ॥

f. 2r V₂

ब्रह्मार्केन्दुवसिष्ठरोमकपुलस्त्याचार्यगर्गादिभि -
 स्तन्त्राण्यष्ट कृतानि तेषु गहनः खेचारिकर्मक्रमः ।
 तद्रत्नाकरवासनाम्बुतरणे सिद्धान्तपोताः कृताः
 श्रीमद्भोजवराहजिष्णुजचतुर्वेदार्यसद्भास्करैः ॥ ४ ॥

5

यज्ञादिकर्मार्थमियं प्रवृत्ता
 |वेदत्रयी दिक्समया|श्रितं यत् ।
 तत्साधनायाद्यमुनिप्रणीतं
 शास्त्रं द्विजैरध्ययनीयमेतत् ॥ ५ ॥

10 p. 2 R₁, f. 2r B₂

Verse 3 numbered 4 M₁M₂ 1 यन्ना] पन्ना R₁ गदितं] कथितं V₂V₅ राननेन] रानने
 V₅ 2 ज्ञानं] ज्ञान V₂ मग्यम्] (म)_{marg}ग्यं B₂, मग्यं R₁ 3-4 शाकल्य—विवृणोमि] top of
akṣaras cut due to error in copying process but no discernible variants from the given text
 V₂ 3 निबद्धं] निबद्ध M₂, निबद्ध[:] O 4 पद्यै] पद्यै M₂ स्वैः] स्रैः M₂, स्वै R₁ **Verse 4**
 numbered 5 M₁M₂ 5 वसिष्ठ] वशिष्ठ R₁V₅ रोमकपुलस्त्या] रोमकपुलस्त्यां V₂, रोमपुलकस्त्या V₅
 चार्य] चार्या(स्तु)_{marg,s} V₅ गर्गादिभि] गर्गादि[x]भि O 6 स्तन्त्राण्य] स्तंशण्य R₁ तेषु] तैषु M₂
 गहनः] corrected from गहनं to गहनः M₁ चारि] वारि M₂ कर्म] वर्म V₂ क्रमः] क्रः
 R₁ 7 तद्रत्ना] तद्रत्नात्ना M₂ तरणे] तरणेः OV₅, तरणे(:)_{supl} R₃ पोता:] पोता(:)_{supl} B₃
 कृताः] कृ(ताः)_{marg} B₂ 8 जिष्णु] जि(ष्णु)_{marg} B₂ वेदार्य] वेदाय M₂ झास्करैः] भास्कराः R₁
Verse 5 numbered 6 M₁M₂ 9 कर्मार्थ] कर्मादि M₁ प्रवृत्ता] प्रवृत्तां M₂ 10 वेदत्रयी]
 वे[त]दत्रयी O, वेदात्रयां R₁ दिक्समया] दिक्षमया R₁ यत्] तत् B₂B₃OR₁R₃V₂V₅ 11 याद्यमुनि]
 यामनु M₁, धनायाद्यमुनि M₂ प्रणीतं] प्रणांत R₁ 12 रध्ययनीय] रः पयनीय M₂, रध्ययनायनाय R₁,
 रध्ययनीय R₃, रध्यनीय V₅

निषिद्धानध्यायाद्यखिलसमये यस्य हि भवे -
 द्वतारम्भो नायं द्विज इति जगुः पूर्वमुनयः ।
 तथा नाड्येकत्वे परिणितवधू सैव भगिनी
 दिशा मूढं कर्माफलमिति च तिथ्यादिषु विधिम् ॥ ६ ॥

f. 2r O, f. 13v M₂

f. 2r B₃

f. 2v V₂

वेदाकारसुरेश्वरो विजयते त्रातुं जगत्तस्य य -
 द्वक्तं व्याकरणं निरुक्तमुदितं श्रोत्रं तथा नासिका ।
 शिक्षा ज्योतिषमीक्षणं करयुगं कल्पो ऽद्विपदद्वयं
 छन्दश्चेति षडङ्गवेदपुरुषो ज्ञेयो ऽर्थतः पाठतः ॥ ७ ॥

5

f. 2r R₃

ज्योतिःशास्त्रं गणितजननप्रक्रियासंहिताभि -
 स्त्रिस्कन्धं तत्त्वचरगणितं तन्त्रमुख्यं निरुक्तम् ।
 सिद्धान्तो ऽसौ ग्रहभवसुधासंस्थितिर्यत्र चाराः
 कल्पे मानान्यपि च गणितं प्रोच्यते सोपपत्ति ॥ ८ ॥

10

Verse 6 1 निषिद्धानध्याया] निषिद्धान्ध्याया B₃R₃, निषिद्धानध्याया O, निषिद्धानध्याया R₁, निषिद्धानध्याया V₅
 यस्य] यस्य R₁ हि] च R₁ 2 द्वाता] द्वाता M₁M₂R₁, द्वाता O नायं] नायं R₁ मुनयः] मनयः R₃
 3 नाड्येकत्वे] नाड्येकत्वे M₁, नाड्येकत्वे M₂, नाड्येकत्वे R₁, नाड्येकत्वे with त्वे marked and the annotation
 तथोदावाड्येकां भवति हि वधू added in the margin R₃ परिणित] परिणित M₁M₂R₁V₅ वधू] वधूः
 B₃OR₁R₃V₂V₅ भगिनी] भगीनि O, भगीनी V₅ 4 दिशा] दिशा M₂ मिति च] मिति च ति च B₂
 तिथ्यादिषु] तिथ्यादि (पु) marg B₂ विधिम्] विधि B₃M₁R₁R₃ **Verse 7** 5 सुरेश्वरो] सुरेश्वरे R₁
 विजयते] पि जयते M₁M₂, विजयतो R₁, विजयते? R₃ तस्य य] तस्य य M₁M₂, तस्या (त) suppl,s V₅
 7 शिक्षा] शिक्षा B₂ ज्योतिष] ज्यौतिष B₃R₃, ज्यो षे ति O, ज्योतिः V₅ 7-8 मीक्षणं—पाठतः] om. but
 inserted in the text itself between marks (see *pāda* b of next verse) V₅ 7 मीक्षणं] मीक्षणे R₁
 युगं] युगं O **Verse 8** 9 ज्योतिः] ज्योति [x](:) suppl B₃, ज्योतिर R₃, om. but part of insert in
 text itself mentioned in the last verse (see *pāda* b) V₅ संहिता] संहिता V₅ 10 स्त्रि] त्रि V₅
 तत्त्व] तं ख M₁M₂, सत्त्व R₁ तन्त्र] (तं) marg त्र B₂, तत्र B₃R₃V₅ मुख्यं] मुख्यं [गणि] M₁, सु [ख] ख्यं
 R₁ निरुक्तम्] निरुक्तं O, after निरुक्तं are an insert in the line itself belonging to the last verse
 and the beginning of this one षमीक्षणं करयुगं कल्पो त्रि पदद्वयं छन्दश्चेति षडङ्गवेदपुरुषो ज्ञेयो र्थतः पाठतः ७
 ज्योति V₅ 11 चाराः] चारा V₅ 12 कल्पे] क [x] ल्पे with ल्पे corrected to this from an illegible
 previous reading O, कल्पो V₅ प्रोच्यते] corrected to this from an illegible previous reading
 B₃, प्रोच्यते O सोपपत्ति] सोप (प) marg ति B₃, सोपपत्ति M₁M₂V₂, लोपपत्ति R₁

प्रकृतिपुरुषयोगाद्बुद्धितत्त्वं त्रिसृष्ट्यै
 प्रथममभवदेतद्गर्भतो ऽहङ्कृतिश्च ।
 |समभवदथ तस्याः शब्दतन्मात्रमस्मा -

p. 3 R₁ & f. 3r V₂,
 f. 2r B₂

द्गगनमथ ततो ऽभूत्स्पर्शतन्मात्रसञ्ज्ञम् ॥ ९ ॥

वायुर्वायो रूपतन्मात्रमस्मा -
 तेजस्तन्मात्रं रसस्यात एव ।
 तोयं तोयाद्गन्धतन्मात्रमस्मा -
 त्पृथ्वी चैषां संहतेर्जातमेतत् ॥ १० ॥

5

|ब्रह्माण्डं तदुदरवर्ति विश्वकर्तुः
 पद्भ्यां भूर्भुव इति नाभितो ऽस्य लोकः ।
 शीर्ष्णो द्यौर्वदनत इन्द्रवह्निसञ्ज्ञौ
 प्राणोत्थः श्वसन इतीरितं च वेदे ॥ ११ ॥

f. 2r V₅

10 f. 2v O

Verse 9 1 बुद्धि] बुद्धि R₁ त्रिसृष्ट्यै] त्रिसृष्ट्यै? B₃, त्रिसृष्ट्यै M₁M₂, corrected from त्रिसृष्ट्यै to त्रिसृष्ट्यै R₁ 2 प्रथम] प्रथम[x] B₂ 3 मस्मा] त्रभस्मा R₁ 4 सञ्ज्ञम्] सं[x]ज्ञं B₂, गर्भ marked and with the variant reading मस्मात् noted in the margin V₂ **Verse 10** 5 वायु] वायू O वांयो] वांयो? B₂ रूप] रू z B₂ तन्मात्र] तन्मात्र V₅ 6 तेज—एव] तेजः सूक्ष्मं रूपमस्माद्रसस्य V₂, तेजः सूक्ष्मं रूपमस्माद्रसस्य V₅ रस] से र O स्यात एव] स्यात्त [ए] एव O 7 द्गन्ध] द्गत M₁M₂ तन्मात्र] तन्मात्र R₁ 8 चैषां] चै z B₂, चैषा M₁M₂R₁V₅ संहते] संहते O मेतत्] मैतत् M₁ **Verse 11** 9 ब्रह्माण्डं] ब्रह्माण्ड R₁ विश्व] विश्व M₁M₂ 10 पद्भ्यां] फ?द्भ्यां O इति] om. M₁M₂R₁ नाभितो] नाभिता M₂ लोकः] लोकाः R₁ 11 शीर्ष्णो] शीर्ष्णो B₂ द्यौ] द्यौ R₁R₃ वदनत] वदिनत M₁M₂, वदनत R₁ वह्नि] वह्नौ R₁ सञ्ज्ञौ] संज्ञो M₁M₂ 12 प्राणोत्थः] प्राणोत्थ B₃M₁M₂, प्राणौच्च? V₅ श्वसन] श्वरान M₁M₂, सन V₅ इतीरितं] corrected from इतिरितं to इतीरितं M₂

इन्दुरस्य हृदयस्थितो ऽभव -
 झास्करो नयनदेशनिवासी ।
 श्रोत्रतो ऽखिलदिशश्च समुत्थाः
 सृष्टिमार्ग इति सम्प्रति कल्पे ॥ १२ ॥

लीनाः प्राक्प्रलये पुराणपुरुषे ये वायवः सप्त ते
 मध्यप्राणविबोधितास्तु पुरुषान्सप्तासृजन्ताथ तैः ।
 भूत्वैकत्र महत्प्रमाणपुरुषः सृष्टः स पद्मोद्भव -
 स्तेनेदं सकलं यथा विरचितं तत्प्रक्रियाथोच्यते ॥ १३ ॥

ब्रह्मादावसृजज्जलं निजगिरस्त्रय्या सहात्राविश -
 त्त्वांशेनाण्डमभूदतो ऽग्निरिह यज्जातं कपालद्वयम् ।
 तत्सङ्कलिश्य जले नियोज्य पृथिवी सृष्टाश्चितस्तां पुन -
 र्वह्न्यंशेन समन्वितो ऽण्डमभवद्वायुश्च तद्गर्भतः ॥ १४ ॥

5 f. 2v B₃ & f. 3v

V₂

p. 4 R₁

10

f. 2v R₃, f. 3r B₂

f. 4r V₂

Verse 12 1 हृदय] हृदया M₁M₂ 2 झास्करो] (द्)_{marg,s} B₃, भास्करो M₁M₂, [x](झा)_{marg} स्करो
 O निवासी] निवासां M₁M₂R₁ 3 श्रोत्रतो] श्रोत्रततो M₂ ऽखिल] ऽखि[ध]ल O दिशश्च]
 दिराश्च M₂ समुत्थाः] समुत्था M₂R₁ 4 कल्पे] चक्रे marked and with the variant reading कल्पे
 given in the margin V₂ **Verse 13** 5 लीनाः] लीना M₂V₅ प्राक्प्रलये] marked but the
 extensive marginalia are mostly illegible B₂ ये] om. but with an insertion mark though
 the marginalia are illegible or destroyed B₂ वायवः] वायव B₃R₃V₅ सप्त] स[x]य V₅
 6 प्राण] (प्रा)_{supl}ण O स्तु] स्त R₁ न्सप्ता] त्सप्ता M₁V₅ सृज] सृत् R₁ थ] य B₃R₃, प्य V₅
 तैः] तै B₃R₃R₁ 7 भूत्वै] भूत्वै M₂, भूत्वै R₁, भूचै V₅ कत्र] क[x](त्र)_{supl} B₂, कत्व B₃ महत्त्र]
 महं प्र B₃R₃, नहत्प्र R₁ स] स[?] M₂ 8 सकलं] सकल R₁ विरचितं] व्यवसितं R₁ **Verse 14**
 9 वसृजज्जलं] वसृजजलं M₁, वसृजं जलं M₂, वसृजज्जल V₅ निजगिर] निजगिरे R₁ स्त्रय्या] corrected
 from स्त्रयं to स्त्रय्या B₃, स्त्रय्या M₁M₂ 10 नाण्डमभू] marked but the extensive marginalia are
 mostly illegible B₂, नाण्डमभू M₁M₂, नाण्डमभू R₁ दतो] द[ग्नि]तो O 11 त्सङ्कलिश्य] त्सक्लिश्य
 B₃R₃ नियोज्य] निजोज्य O पृथिवी] पृथिवी M₁M₂, पृथिवी R₁ सृष्टा] सृष्टा[x] B₃, सृष्टा M₂
 अत्र] स्थित V₂V₅ स्तां] स्तं B₃R₃ 12 र्वह्न्यं] र्वह्न्यं R₁, र्वह्न्यं R₃ समन्वितो] समान्वितो
 B₂B₃M₁M₂, सम x तो O, समन्वितो R₃ तद्गर्भतः] त(द्ग[?])_{marg}र्भतः B₂

अत्रैवाण्डकपालतः समभवद्वोमाथ तत्राश्रितः
 स्वांशं स वायुनाण्डमकरोत्सूर्यो ऽयमस्मादभूत् ।
 द्यौरत्राण्डकपालतो ऽथ शकले लिप्ताद्रसाद्रश्मय-
 स्तामाश्रित्य दिवाकरांशसहितः स्वांशेन चाण्डं बभौ ॥ १५ ॥

तदण्डगर्भात्समभूद्धिमांशु-
 रिहाम्बु यत्सङ्घरितं ततो ऽभूत् ।
 तारागणस्तच्छकलाद्दिशस्तु
 तल्लिप्तसत्त्वाद्विदिशस्तथैव ॥ १६ ॥

सृष्ट्वा लोकान्वाङ्मनोयोगतस्तु
 मासैरष्टावष्टसङ्घैर्वसूँश्च ।
 एवं रुद्रान्द्वादशार्कानपीत्थं
 विश्वेदेवान्विश्वकर्तासृजत्सः ॥ १७ ॥

Verse 15 numbered 16 V₅ 1 समभव] समभ(व)_{marg} B₂, corrected from समभवे to समभव M₁ द्वोमाथ] द्वोमापि M₁M₂, द्वोमाय V₅ 1-2 तत्राश्रितः स्वांशं योज्य] तत्राश्रितो x संयोज्य B₂, तत्राश्रितो ऽयं स्वं योज्य M₁M₂, तत्राश्रितो शं संयोज्य O 2 मकरोत्सू] मकरो सू M₁M₂ मस्माद] मास्माद B₃ 3 द्यौरत्राण्ड] द्यौरशंड B₃, द्यौरशंड R₃ शकले] शकला B₂M₁M₂O लिप्ता] marked and the annotation शकल x रा लिप्तश्चासौ (rest unavailable due to copying process) added in the margin B₂ द्रसाद्रश्मय] द्रसा x श्मय B₂, द्रसा राश्मय M₁, द्रसा रश्मय M₂OR₁V₅ 4 स्तामा] marked and the annotation दिवं added in the margin B₂, स्ताना B₃R₃, स्त(र)श्चा with स्तांश्चा added in the margin to make the reading clear V₂ दिवाकरांश] दिवाकरांश V₅ सहितः] सहित B₂ चाण्डं] चांडं M₂, चांडौ R₁, चांडा? V₂ बभौ] (व)_{marg}भौ V₂ **Verse 16** numbered 17 V₅ 5 तदण्ड] नदंड R₃, अंडस्य V₂, अंडदंड V₅ गर्भा] [ग]गर्भा B₂, corrected from गर्भरं to गर्भा V₅ द्विमांशु] द्विमांशु M₂, द्विमां x O 6 ततो] तो V₅ 7 गण] गणा M₁R₁V₅ स्तच्छ] स्तच्छ B₂, स्तत्स V₅ कलाद्दिश] क[र]ला दिश B₂, कला दिश B₃M₁M₂R₁R₃V₂V₅ 8 तल्लिप्त] तल्लिप्त M₂, तल्लिप्त? O सत्त्वा] शत्त्वा V₅ स्तथैव] श्व तद्वत् M₁M₂, स्ततो पि V₂, स्तु वेद्याः V₅ **Verse 17** numbered 18 V₅ 9 सृष्ट्वा] सृष्ट्वा V₅ झनो] झनो? B₂ योगतस्तु] योग(ज)_{marg,s}स्तु V₅ 10 सङ्घै] संख्य B₂ 11 रुद्रान्द्वाद] रुद्रा द्वा(न)_{marg}द B₃, रुद्रान्द्वाद M₂ शार्कान] शार्कन R₁ 12 विश्वे] corrected from विश्वे to विश्वे M₁ सृजत्सः] सृ(ज)_{marg}त्सः B₂

अदधादनलं वसूँश्च भूमौ
मरुतं रुद्रगणं नभस्यथो ऽर्कान् ।
दिवि सूर्यसमन्वितान्विधाता
शशिनं देवयुतं दधार दिक्षु ॥ १८ ॥

f. 3r B₃

इति शतपथवेदे षष्ठकाण्डाद्यपाठे
पठित इह विशिष्टः सृष्टिमार्गः प्रदिष्टः ।
उभयविभवयोः स्यादैक्यमीद्वैर्विचारैः
क्वचिदपि यदि भेदः कल्पभेदेन वेद्यः ॥ १९ ॥

5 p. 5 R₁

f. 3v B₂

f. 14r M₂

इति सृष्टिक्रमः

कल्पादितो युगमहीधरवेद ४७४ वर्षै-
र्दिव्यैः शतेन गुणितै रचितं क्रमेण ।
भूमण्डलार्णवमहीधरखेचराद्यं
न्यस्तास्ततो भवलये निखिला ग्रहेन्द्राः ॥ २० ॥

10

f. 5r V₂

Verse 18 numbered 19 V₅ 1 अदधाद] अदधा[xxx]द O नलं] लनं M₁M₂ वसूँश्च] वसूँश्च R₁ 2 मरुतं] मरु(तं)^{supl} O रुद्र] (रु)^{marg}द्र O स्यथो ऽर्कान्] स्यथार्कान् R₁, स्यतो कान् V₂ 3 समन्वितान्वि] समन्वि [x](तांन्वि B₂, मन्वितान्वि B₃, समन्वितं वि M₁M₂, समान्वितान्वि R₁, समन्वि V₅ धाता] यता V₃ 4 दिक्षु] दि[सू]क्षु O **Verse 19** numbered 17 O, numbered 20 V₅ 5 शत] श w B₂ षष्ठ] षष्ठ B₃M₁OR₁R₃V₂ काण्डाद्य] डाद्य M₂, काड्याद्य R₁, कां[x]ड्याद्य V₅ पाठे] पादे M₂ 6 पठित] (प)^{marg}ठित O विशिष्टः] वशिष्टः B₃, वसिष्टः M₁, वसिष्टः M₂, समस्तं R₁, वशिष्टः V₅ सृष्टि] (सृष्टि)^{marg} B₂ मार्गः] मार्गं(:)^{supl} B₃, मार्ग M₁R₁ 7 उभय] w भय B₂ विभवयोः] विभवयो M₁R₁, marked and the annotation सृष्ट्योः added in the margin O स्यादैक्यमी] स्यादैक्यमी M₁M₂, [(xx)क्रमः किभ्यः? हितो पुममहीधरवेदचर्यर्दिव्यैः] शतेन स्यादैक्यमी with चर्य marked though no marginalia is found O मीद्वैर्वि] मीद्वैर्वि R₁, माद्वैर्वि V₅ 8 क्वचिदपि] क्वचिदपि V₅ भेदेन] भेदे w B₂, x देन B₃, भे(दे)^{marg}न O, भेदेऽन R₃, भेदेभे with the last भे marked and the reading न added in the margin V₂ वेद्यः] w द्यः B₂, बोध्यः R₁ 9 इति सृष्टिक्रमः] om. B₃R₁R₃V₁ **Verse 20** numbered 21 V₅ on f. 12r V₁ 10 कल्पा] कल्पो M₁M₂, कभ्या O ४७४] वर्षैः ४७४ B₂, वर्षै ४७४०(०)^{supl} B₃, om. OV₁V₂, वर्षैः ४७४०० R₁, वर्षै ४७४ R₃, ४७४०० V₅ 11 दिव्यैः] x व्यैः marked and with the annotation दिव्यैरित्यनेन षष्ठ्यधिकशतत्रये ३६० न पुनः गुणितैः कृत्वा सज्जनकालो ज्ञेयः added in the margin B₂, marked and ४७४०० added in the margin V₂ 12 लार्णव] लार्कव M₁, ल(र्)णं [x] O 13 स्ततो] (स्त)^{marg}तो B₂, ततो M₁ भवलये] भुवलये O, भवभये R₁ निखिला] निखिल V₁V₂

भूगोलः किल वर्तुलो जलधयस्तन्मेखलावस्थिता
यस्मिन्देवनरासुराद्रितरवस्तिर्यक्च पृष्ठे तले ।
यद्वत्केसरधृक्कदम्बकुसुमग्रन्थिस्तथायं दध-
त्वे तिष्ठत्यचलो ऽवतारपुरुषैरात्तातिभारः परः ॥ २१ ॥

लङ्कापुरोपरिगतः खचरः सुमेरो-
र्याम्ये कुजे ऽथ यामकोटिगतस्य पश्चात् ।
प्राग्रोमके च वडवानलतस्तु सौम्ये
यस्मात्ततो भवति भूः खलु गोलरूपा ॥ २२ ॥

5 f. 3r R₃

f. 3r O

f. 2v V₅

इति यमवनिकन्दुकाकृतित्वे
समुदितवान्हि पृथूदकः सुहेतुम् ।
न भवति स यतः प्रमाणसिद्धः
खलमतयस्तमतो न मानयन्ति ॥ २३ ॥

10

p. 6 R₁

Verse 21 numbered 22 V₅ on f. 12v V₁ 1 गोलः] गोला M₂ स्तन्मेखला] स्तन्मेखला
O, स्तन्मेखला V₁, स्तस्मिखला V₅ वस्थिता] व (त्)_{marg} स्थिता B₃, व x ता O 2 नरा] नराः R₁
तरव] नरव M₂, तख R₁ स्तिर्यक्च] स्तिर्य x B₂O, तिर्य्यक् R₁ 3 यद्व] तद्व M₂, पद्व R₁ धृक्]
दृक् M₁R₁, धृत्क V₁ कुसुम] कुसम R₁ थायं] थात R₁, थाये V₅ दध] दध R₁ 4 पुरुषैरात्ता]
पुरुषेराता M₁M₂, पुरुषैरान्ता R₃, पुरुषस्यात्ता with षस्याता marked and the variant reading षैरात्ता added
in the margin V₂, पुरुषैराह्? V₅ तिभारः] तिभारः O परः] om. but added in margin B₂
Verse 22 numbered 23 V₅ on f. 13v V₁ 6 ऽथ] च M₁M₂ कोटि] corrected
from केटि to कोटि V₁ गतस्य] गतश्च R₁ 7 च] थ B₃R₃ तस्तु] तश्च B₃, त (श्च)_{marg} R₃
8 यस्मात्ततो] वस्मादतो M₁, यस्मादतो M₂ भूः] [x] भूः B₂, भू R₁ गोलरूपा] (गोल)_{marg} रूपा
B₂, corrected from गोलगपा to गोलरूपा M₁, गोलरूपाः R₁ **Verse 23** numbered 24 V₅
on f. 14v V₁ 9 इति] इ [f] त (ः) B₂ यमवनि] यम (व)_{marg} नि B₂, समवनि V₂ कृति] कृत R₁
10 वान्हि] वा (न्)_{marg} हि B₃, वान्न हि M₁M₂, वांस्तु R₁ पृथूदकः] पृथुदकः B₃, पृथूदका M₁, पृथूदकाः M₂,
पृ [x] धूदकः O सुहेतुम्] सहेतुं V₅ 11 न भवति स यतः] नव भवति खलु यत V₅ सिद्धः] सिद्धाः B₂
12 खल] ख B₃R₃ मतय] (म)_{marg} तय B₃, मृतय M₁M₂, मतयः R₁ न मान] नुमान B₃R₃

भूद्वर|वर्त्यच|लकोन्नमना समान-
तुल्योप|लब्धिजनिका प्रतियोजनं भूः ।
यातुः क्रमेण कथिता ध्रुवसम्मुखस्य
तिर्यङ्मुखस्य च कपित्थनिभात एव ॥ २४ ॥

f. 3v B₃, f. 4r B₂

f. 5v V₂

उत्तानपादतनयाभिमुखं प्रयातुः
खार्धान्नतं भवति दक्षिणतो भचक्रम् ।
सौम्यध्रुवोन्नमनमेकलवाधिकं स्या-
दस्येन्द्र १४ योजनगतस्य निजप्रदेशात् ॥ २५ ॥

5

Verse 24 numbered 25 V₅ on f. 15r V₁ 1 भूद्वर] corrected from भूद्वरु to भूद्वर B₂, भूद्वर[x] B₃ वर्त्य] वस्य B₂ चल] च[च]ल B₂, चलं M₁ कोन्नमना] कोन्न[न]मना B₂ समान] समान[र] R₁ 3 यातुः] यातुः? O, पातुः R₁R₃, यातु(:)supl V₁ क्रमेण] क्रमेण V₅ सम्मुखस्य] सन्मुखस्य M₁M₂OR₁ 4 निभात] निभात O **Verse 25** numbered 26 V₅ on f. 15r V₁ 5 उत्तानपादतनया] marked and the annotation ध्रुवाभिमुखं added in the margin by s R₃ उत्तानपाद] marked and the annotation ध्रुवः added in the margin B₂ तनया] तनया V₂ भिमुखं] भि(मु)_{marg}खं V₂ 6 धान्नतं] corrected from द्वान्नतं to द्वान्नतं V₁ दक्षिणतो] दक्षि(ण)_{marg}तो B₂ 7 सौम्य] सौम्ये R₁, corrected from सौम्ये to सौम्य V₂ ध्रुवोन्नमन] ध्रुवोन्नमन M₁, ध्रुवो[त्त]न्नमन O, ध्रुवोन्नमन O मेकलवा] मेक[x](ल)_{supl}वा O 8 दस्येन्द्र] दस्ये[x]द्र V₂ १४] om. B₂M₁M₂OR₁V₁V₂V₅ प्रदेशात्] प्र[x]देशात् V₂

सूर्ये पूर्वकुजाश्रिते ऽतिगतिमान्गन्तुं प्रवृत्तः पुमा -
 न्पूर्वाशां करसङ्गृहीतसिकतायन्त्रो ऽभ्रभू १० योजनैः ।
 सेष्वंशाद्रि ७ । १२ पलाधिकं तु समयं ज्ञात्वा स्वकीयोदया -
 ज्ञाता तेन मही हि कन्दुकनिभा या^(a) पञ्चसाहस्रिका ५००० ॥ २६ ॥

सङ्गोलपदं पुराणपठितं दृष्ट्वा तथा सर्वतो
 मेरुः सौम्यदिशीति चाग्रहरता जल्पन्ति ये मानवः ।
 भूरादर्शतलोपमेति सकला ते ऽर्थं पुराणोदितं
 नो जा|नन्ति च सूपपत्तिविदितां |सत्कन्दुकाकारताम् ॥ २७ ॥

5

f. 6r V₂

f. 4r O, f. 4v B₂

Verse 26 numbered 27 V₅ on f. 15v V₁ 1 पूर्व] प्राचि B₃R₃ ऽतिगतिमा] त्तिमा with an insertion mark between these two syllables but the corresponding marginalia is missing or destroyed B₂ नान्तु] नान्तु [xx] B₂, नान्तु: M₁M₂, नान्तु? with गंतुं added in the margin to make the reading clear O, (न)_{marg}गंतुं R₃, ना[x]तुं V₁ प्रवृत्तः] प्रवृत्तः V₅ 2 न्यूवांशां] न्यूवांशां M₁, न्यूवांशां M₂ सङ्गृहीत] संग्रहीत M₁M₂R₁V₅ सिकता] सितका M₁M₂, सिक[r]ता O ऽभ्रभू] (ऽ)_{supl}भ्रभू V₁, भ्रभू V₅ १०] योजनैः १०। ७। १२ B₂, ऽभ्र १० भू B₃R₃, १० योजनैः १०७ M₁M₂, योजनैः १० १२ O, om. R₁V₁ योजनैः] योजनैः V₅ 3 सेष्वंशाद्रि] शेष्वांशाद्रि B₂O, येष्वांशाद्रि M₁M₂, marked with ५० ७ and in the margin R₃, marked and ७ added in the

वि० १२

१२

margin V₂ ७। १२] om. B₂B₃M₁M₂OV₁, प ७ ला R₁, ७ १ V₅ स्वकीयोदया] स्वकी दे यो M₁

4 ज्ञाता] ज्ञाता B₂, ज्ञात्वा M₁, तज्ञात्वा M₂, तज्ञाना V₅ तेन] (ऽ)_{supl}नेन B₃ कन्दुक] कंदुक[r] V₂ या] यः B₂B₃OR₃V₁V₅, भू M₁V₂, भू: M₂ ५०००] om. B₂OR₁R₃V₁V₅, पंचसाहस्रिका V₅

Verse 27 numbered 28 V₅ on f. 16vs V₁ 5 सङ्ग] सभू R₁ पद] पद B₂ सर्वतो] वंतो though स could have been in the broken margin B₂, सेनो R₁ 5-7 तो—दर्श] om. M₁M₂ 6 चाग्रहरता] चग्रहठरो V₅ जल्पन्ति] corrected from जेल्पन्ति to जल्पन्ति O 7 रादर्शत] राशं(त)_{marg} though the द could have been in the broken margin B₂ तलोपमेति] तामपमेति followed by a blank space corresponding to about 12 akṣaras M₁M₂ सकला ते] सकलति M₂ दितं] दिनं O 8 सूपपत्ति] भूपपत्ति R₁ विदितां] वि w w B₂, विदिता M₂, विदिनां R₁ सत्कन्दुका] सत्कंदुका V₅ कारताम्] कारता M₁, कारितं V₅

(a). Note that while a majority of manuscripts have the reading यः in *pāda* d, a reading also followed by Cīntāmaṇi, this is a very awkward place for that word, for which reason the reading या, though only attested in one manuscript, has been adopted.

मुकुरतल।निभत्वं यत्पुराणप्रदिष्टं
तदवनिशतभागस्यैव नो भूमिगोले ।
परिधिशतविभागो दण्डवद्दृश्यते ऽतः
सम इव म।नुजानां भाति गोलो धरित्र्याः ॥ २८ ॥

p. 7 R₁

f. 4r B₃

मूर्ते कुधर्तरि भवेदनवस्थिकातः
स्वाभाविको गुण इति स्थिरता स्थिरायाम् ।
औष्ण्यं यथानलगुणो द्रवतोदकस्ये-
त्युक्तं हि भास्करकृतौ तदतो न युक्तम् ॥ २९ ॥

5

f. 3v R₃

गोत्राचारधराः पुराणपठिताः शेषादयः सन्तु तैः
को दोषः खचरोडुपञ्जरगतौ वेदोदितास्ते यतः ।
भूमौ चेदचलत्वलक्षणगुणः किं नो तदंशे ।पुन-
स्तोयांशे द्रवता यथानललवे दाहत्वमित्यादिवत् ॥ ३० ॥

10

f. 6v V₂

Verse 28 numbered 29 V₅ on f. 17r V₁ 1 मुकुर] मुकर V₅ त्पुराण] पुराणे R₁
2 तदवनि] त [x](द)^{supl}वनि O भागस्यैव नो] भा w w w B₂ गोले] corrected from गोलो
to गोले V₁, गोलो V₅ 3 शत] श[r]त V₁ विभागो] corrected from विभागे to विभागो B₃
दृश्यते] दृश्ये B₂, द्र²श्यते V₅ 4 इव] हव V₅ गोलो धरित्र्याः] गो w w रित्र्याः B₂ **Verse 29**
numbered 30 V₅ on f. 17v V₁ 5 कुधर्तरि] corrected from कुधर्तरि to कुधर्तरि V₁
दनव] द(न)^{marg}व B₂ स्थिकातः] स्थिका(ऽ)^{supl}तः B₃, स्थिकात V₅ 6 स्वाभाविको गुण इति]
स्वाभाविकः खलु गुणः V₅ स्वाभाविको] स्वाभाविको O गुण] गुणा R₃ स्थिरायाम्] marked and the
annotation भूमौ added in the margin by s B₃, स्थिराया M₁M₂ 7 औष्ण्यं] औष्ण्ये M₁, उष्ण्ये V₅
यथानल] यथानिल V₅ 8 भास्कर] [x] (भा)^{marg}स्कर O तदतो] तद(ऽ)^{supl}तो B₃ **Verse 30**
numbered 31 V₅ on f. 18r V₁ 9 गोत्रा] marked and the annotation भूमिः added in
the margin by s B₃ चार] भार B₃ धराः] धरा(:)^{supl} B₃, धरा R₃ सन्तु] संतु? O, संतु V₁
10 दोषः] दोषः [x] B₂, corrected from देशः to दोषः V₁ चरोडु] चरो(डु)^{marg,s} B₃, चरोड R₃
वेदोदितास्ते] वेदोदि x स्ते B₃, वेदोदितास्ते R₁, वेदोदिवास्ते R₃ 11 भूमौ] भौमो V₅ दचल] दनल M₁M₂
लक्षण] [xx] (अक्ष)^{marg,s}ण O गुणः] गुणाः V₅ किं नो] किं चो B₃, किं नौ M₁, किं नौ M₂, किं चो R₃
पुन] न but the पु might have been there as the margin is damaged B₂ 12 स्तोयांशे द्रवता]
स्तोयांशे [पुनस्तोयांशे] द्रव [व] ता B₂ दाह] दाद्य M₁M₂O, दाद्य with द्य marked and the variant
reading ह² added in the margin V₂, दाक्र V₅

धृतवक्त्रसरीसृपो ऽपि गृध्रः
 प्रहरं तिष्ठति खे ऽल्पवीर्य एवं ।
 गगने न कथं स कूर्मरूपः
 प्रतिकल्पं धृतभूरचिन्त्यशक्तिः ॥ ३१ ॥

आकृष्टशक्तिश्च महीति^(a) न स्या-
 द्यतो घनं शीघ्रमुपैति भूमिम् ।
 आकर्षकं याति लघु द्रुतं हि
 मही स्थिरा धारमृते कथं स्यात् ॥ ३२ ॥

भूगोलार्धं क्षारसिन्धूपरिष्ठं
 मेरुर्देवा यत्र तिष्ठन्ति नित्यम् ।
 नूनं तस्यैवोर्ध्वता यत्र दैत्या-
 स्तस्मिन्प्रोक्ताधःस्थितिः सत्पुराणे ॥ ३३ ॥

5

10 f. 5r B₂

f. 4v O

f. 3r V₅, f. 14v M₂

Verse 31 numbered 32 V₅ on f. 20r V₁ 1 गृध्रः] गृध्रः R₁ 2 प्रहरं] प्रहर(न्)_{marg,s} B₃, [त] १ [भूरचिन्त्यशक्तिः] रं O एवं] एव B₃ 3 कथं] कथं O कूर्म] कुर्म O 4 कल्प] कल्प⁷ with ल्प added above the line to make the reading clear O भूरचिन्त्य] भू[fi]रचित्य B₂, भू(ऽ)_{supl}रचित्य B₃, भूरचित्य M₁M₂, भूरपि चित्य V₅ शक्तिः] शक्ति O **Verse 32** not numbered V₁, numbered 33 V₅ on f. 22r V₁ 5 आकृष्टशक्तिश्च महीति न स्या] आकृष्टशक्तीति महीनिनश्चा V₅ आकृष्ट] आकृष्ट[ष्ट] V₁ महीति न] महीति [xx] न B₂, मही[fi]तल B₃, महीतिव? O, महीतिल R₃ 6 द्यतो] दतो B₂, धतो M₁M₂, corrected from द्यतो to द्यतो O घनं] पनं M₁M₂, घनं V₅ भूमिम्] [x] भूमिं B₂, भू[x](मि)_{marg,s} B₃, नूनं V₅ 7 आकर्षकं] आकर्षयं R₁ लघु द्रुतं] with घु missing and a mark for a marginal insertion which is missing due to damage B₂ **Verse 33** numbered 32 B₃R₃, numbered 34 V₅ on f. 22v V₁ 9 गोला] corrected from गोल to गोला V₁ क्षार] क्षारर O परिष्ठं] परि (rest destroyed with margin) B₂, परि [भद्यु] स्टऽ O, प[fi]र(र्)ष्टं V₂ 11 नूनं] न्यूनं B₂B₃M₁M₂R₁R₃ वोर्ध्वता यत्र] वोर्द्धतान्यत्र B₃R₃, चोर्ध्वतो न्यत्र M₁M₂, वोर्द्धतान्यत्र O, वोर्द्धता यत्र R₁V₁V₅, वोर्द्धता यत्र V₁ 12 स्तस्मि] तस्मि M₁ क्ताधः] क्ताध M₁M₂R₁V₅, क्ताध(:)_{supl} V₁ स्थितिः] स्थितः V₅ सत्पु] स्यात्पु with स्या marked and the variant reading स added in the margin V₂, x त्पु V₅

(a). आकृष्टशक्तिश्च मही तथा यत्स्वस्थं गुरु स्वाभिमुखं स्वशक्त्या । आकृष्यते तत्पततीव भाति समे समन्तात्क पतत्वियं खे ॥ (*Siddhāntaśiromaṇi*, *golādhyāya*, *bhuvanakośa*, 6). Note that the reading in the *Siddhāntaśiromaṇi* is आकृष्टशक्ति, which is better than आकृष्टशक्ति.

इति चेन्न पतन्त्यधःस्थिताः किं
गिरयः सिन्धुसरिन्नराः ख एते ।
अधृतं गुरुवस्त्वचेतनं य-
त्तदधः सम्पततीति दृश्यते । ८तः ॥ ३४ ॥

f. 4v B₃

।नाशङ्कनीयमिति वस्तुनि ।देशभेदा-

5 f. 7r V₂, f. 10v
M₁

त्सामर्थ्यलक्षणगुणाः कतिचिद्विभिन्नाः ।
यद्वत्सुशीतलकराश्मशिला द्रवन्ति
सूर्याश्मनिर्मलशिलास्वनलप्रवृत्तिः ॥ ३५ ॥

f. 23r V₁

वज्राणि वारिषु तरन्ति हि चुम्बकाश्मा
लोहं समानयति चात्मविद्वरवर्ति ।
उच्चैस्तरं भवति पर्वतवत्समुद्रे
नीरं यतो बत विचित्रगुणाः प्रदेशाः ॥ ३६ ॥

10

Verse 34 numbered 33 in margin by s B₃, numbered 33 R₃, numbered 35 V₅ on
f. 22v V₁ 1 पतन्त्यधः] पतन्त्यध R₁ 1-2 स्थिताः किं गिरयः] स्थिता (गि)_{marg,s} [x] रयः
B₂, स्थिता किं गिरयः R₁ 2 सरि] सरी M₁M₂ न्नराः] न्नरः? B₂, न्न²रा V₅ 3 धृतं] zz B₂
गुरुव] गुरुव M₁M₂, गु(रु)_{supl}व O स्त्व] marked and स्त्व given again in the margin to make
the reading clear V₁ 3-4 यत्त] पन्त O, यस्त R₁ 4 सम्पततीति] संपतीति O दृश्यते] दश्यते V₅
Verse 35 numbered 34 B₃R₃ on ff. 22v-23r V₁ 5 नाशङ्क] corrected from नांशंक
to नाशङ्क O नि देश] निदेव V₅ 5-6 भेदात्सा] लेदात्सा R₃, भेदा सा V₅ 6 लक्षण] लक्षणा V₁
गुणाः] गुणा(:)_{supl} B₃ चिद्वि] चि w B₂ 7 यद्वत्सु] यद्वस्तु B₃M₁M₂, यद्वस्तु R₃ राश्म] रा
z B₂ 8 शिलास्वनल] शिलास्व(ऽ)_{supl}नल B₃, शिलाः खनल M₁M₂, शिला खनल R₁, शिलास्तनल V₅
वृत्तिः] वृत्ति?_[x] B₂ **Verse 36** numbered 35 B₃R₃ on f. 23r V₁ 9 वज्राणि]
marked and the annotation हरिकाणि added in the margin by s B₃ चुम्बकाश्मा] चुं²काश्मा B₂,
चुंबुकार M₁M₂, चुंबकाश्म R₁V₂, चुबकाश्मा V₁ 10 समानयति] समालयति M₁M₂ विद्वर] निद्वर V₁V₅
वर्ति] वा²त्ति? M₁, वाती? M₂, वर्त्ती R₁, वृत्तिः V₅ 11 भवति] भुवति O पर्वत] पर्वतव O, corrected
from पर्वते to पर्वत V₁, पर्वते V₅ वत्समुद्रे] [x](त्स)_{marg}मुद्रे O 12 यतो बत] यतो बत M₁, यतो बत
M₂, यतो बत R₃ बत विचित्र] जगति चित्र V₂

भाषाकाराचारसामर्थ्यभेदो
ह्यत्रैवार्धे देशभेदेन दृष्टः ।
नृणामेवं किं पुनर्नान्यभागे
तस्मात्स्थैर्यं नाम शक्तिश्च तेषाम् ॥ ३७ ॥

किं नो ऽमुना बहुतरेण मुधोदितेन
गुर्वी स्थिरा वियति येन धृतेयमुर्वी ।
सर्वं धराधरचरं धरतीति भाति
देवो ऽधरायणनिवारणतो ऽवतीर्णः ॥ ३८ ॥

क्षारपयोनिधितः परतो ऽस्ति
क्षीरनिधिर्दधितो घृतसिन्धुः ।
इक्षुरसार्वमद्यमयाब्धी
तत्परतः सुजलो जलराशिः ॥ ३९ ॥

5

10 p. 9 R₁

f. 5r O

Verse 37 numbered 36 B₃R₃, not numbered R₁, numbered 38 V₅ on f. 23v V₁
1 काराचार] वाराचार B₂B₃, काराच्चार M₁M₂ सामर्थ्य] सामर्थ्या B₂, सामर्थ्य[र] M₁ 2 ह्यत्रै] द्यत्रै
V₅ देश] दशं V₅ दृष्टः] दृष्टं V₅ 3 नृणा] z णा B₃, नृणा M₁M₂V₂V₅ मेवं] मेषं B₃R₃
Verse 38 numbered 37 B₃R₃, not numbered V₁, numbered 39 V₅ on f. 25r V₁
5 तरेण] तरण R₁ दितेन] दिते M₁ 6 गुर्वी] गुवी M₁ स्थिरा] w रा B₂ वियति] विवति
B₃R₃ मुर्वी] मूर्वी B₂, मुवी M₁M₂V₁ 7 धराधर] धरा(ऽ)^{supl}धर V₂ चरं] धरं B₃R₁R₃,
x (च)^{supl}रं with चरं added in the margin V₂ 8 देवो] दैव V₅ अधरायण] धरायण B₃R₃V₅
निवारणतो] w वारणतो B₂, निवारणतो O ऽवतीर्णः] corrected from वतीर्णं to वतीर्णः O **Verse 39**
numbered 38 B₃R₃, numbered 40 V₅ on f. 25v V₁ 9 निधितः] मि²धितः B₂, निधिरतः V₅
10 निधि] निषि R₁ दधितो घृतसिन्धुः] दधियुग्घृतसिं w B₂, घृतयुक्दधिसिन्धुः B₃R₃, दधियुक्घृतसिन्धुः M₁M₂,
दधियुग्घृतसिन्धुः OR₁, दधिसिन्धुघृताब्धी V₂, दधिजोघृतसिन्धु V₅ 11 इक्षुरसा] इक्षु(र)^{marg}सा B₂, इ [x]
क्षुरसा O मद्य] मध्य R₁, with द्य added in the margin to make the reading of the last *akṣara*
clear V₁ मयाब्धी] मयाब्धि M₁M₂, पमाब्धि R₁, पयो[f]ध(र्) with धी added in the margin to
make the reading clear V₂, मयोब्धी² V₅ 12 तत्परतः] तत्परतो M₁M₂, corrected from स्तत्परतः
to तत्परतः V₂ जल] ज V₁

सुजलजलधिमध्ये वाडवो ऽग्निः स्थितो ऽस्मा -
 त्सलिलभरनिमग्नादुत्थिता धूममालाः ।
 वियति पवननीताः सर्वतस्ता द्रवन्ति
 द्युमणिकिरणतप्ता विद्युतस्तत्स्फुलिङ्गाः ॥ ४० ॥

जम्बूद्वीपं मेखलावस्थितस्य
 क्षारा।म्भोधेरुत्तरं यद्भवोर्ध्वम् ।
 एवं याम्यार्धे समुद्रद्वयान्तः
 सर्वत्र स्याद्वीपषट्कस्य संस्था ॥ ४१ ॥

5

f. 27v V₁

शाकं तस्माच्छाल्मलं कौशमस्मा -
 त्कौञ्चं गोमेदं तथा पुष्कराख्यम् ।
 जम्बूद्वीपे मध्यसंस्थाः प्रदेशा
 वर्षाख्याः स्युस्ते।न वात्र प्रदिष्टाः ॥ ४२ ॥

10

f. 8r V₂

Verse 40 numbered 39 B₃R₃, numbered 41 V₅ on f. 26v V₁ 1 जलधि] ज (ल)_{marg} धि B₂O वाडवो] वा w बो B₂ ऽग्निः] ग्नि M₁R₁V₅ 2 भर] मर M₁, तर V₅ दुत्थिता] corrected from दुत्थित to दुत्थिता B₃, दुत्थित R₃ मालाः] माला R₁V₂V₅ 3 नीताः] नीता R₁V₁V₅ द्रवन्ति] द्रवन्ति R₁ 4 किरण] किरणि R₁R₃ विद्युत] वित M₂ स्तत्स्फु] स्तस्फु R₁
Verse 41 numbered 40 B₃R₃, numbered 42 V₅ on ff. 27r-27v V₁ 5 जम्बू] जंबु M₁, जंबू V₅ 5-6 लावस्थितस्य क्षाराम्भो] लावस्थितस्य [xxx] क्षारां [x] भो B₂, लावस्थितस्य क्षारां [व] भो M₁, लावस्थितस्य[?]क्षारांभो O, लावस्थितस्य क्षारांभो R₃, लावद्विल [त x] (ग्नं क्षा)_{marg} रांभो V₁ 6 रुत्तरं] रुत्तर R₁ वोर्ध्वम्] वोर्ध्व B₂B₃OR₁R₃V₂, वोर्ध्व M₁M₂, वोर्ध्व V₁ 7 एवं] एव R₁ समुद्र] समुद्र V₂ 8 स्याद्वीप] स्याद्वीप M₁M₂R₁V₂V₅ संस्था] (सं)_{marg} स्था O **Verse 42** numbered 41 B₃R₃, numbered 43 V₅ on f. 27v V₁ 9 शाकं] छाकं R₁, शाकं V₁ च्छाल्मलं] छाश्मलं M₁M₂, छाल्म [r]लं O, with ल्म marked and ल्म written in the margin to make the reading clear V₁ कौशम] कौश्म[?] V₅ 10 त्कौञ्चं] त्कौच R₃, त्कौच V₂ 11 द्वीपे] द्वीप M₁R₃, द्वीपं M₂ संस्थाः] संस्था R₁V₅ प्रदेशा] प्रदेशाः R₁ 12 वर्षाख्याः] वर्षाख्या M₁M₂V₅, वर्षा[?]ख्याः O, वर्षाख्या (:) _{supl} V₁ वात्र] वात्रः M₁ प्रदिष्टाः] प्रदिष्टा R₁

खवह्निभू १३० योजनविस्तृते ऽब्धौ
लङ्कापुरं प्राग्यमकोटिरस्मात् ।
भूतुर्यभागे ऽस्ति ततस्तु सिद्ध-
पुरं ततो रोमकपत्तनं च ॥ ४३ ॥

याम्येन तेभ्यः खलु वाडवाग्निः
सौम्येन मेरुस्त्विति षट्प्रदेशाः ।
लङ्कापुरादुत्तरतो हिमाद्रिः
स्याद्धेमकूटो निषधस्ततो ऽपि ॥ ४४ ॥

सिद्धाभिधात्पत्तनतस्तथैव
सच्छृङ्गवाञ्छुक्कगिरिः सुनीलः ।
दैर्घ्येण पूर्वापरसिन्धुलग्ना -
स्तदन्तरे वर्षनिवेश एवम् ॥ ४५ ॥

5

10 p. 10 R₁

f. 5v O

Verse 43 numbered 42 B₃R₃, numbered 44 V₅ on f. 27v V₁ 1 ख] ख[ख] M₁ १३०] योजन १३० B₂O, om. R₁V₁V₅ विस्तृते] विसृते V₅ 2 लङ्का] [x] लंका B₂ ग्यम] ग्य(म)_{marg} B₃, ग्यव R₃, ग्यमे V₁ कोटिर] कोटि then an *akṣara* corrected to र then about three erased *akṣaras* B₂, कोटित V₅ स्मात्] स्यात् M₁M₂ 3 भूतु] corrected from भूभू to भूतु R₁ भागे] भागो R₁ तत] तंत R₃ सिद्ध] सिद्धं B₃R₁R₃V₁V₂V₅ 4 पत्तनं] पट्टणं M₁M₂ **Verse 44** numbered 43 B₃R₃, numbered 45 V₅ on f. 28r V₁ 5 खलु] corrected from खभु to खलु O वाडवा] वाडवो R₁ 6 मेरु] तेरु M₁ स्त्विति] स्थिति O षट्प्रदेशाः] षट्प्र z शाः B₂, षट्प्रदेशा O, (ष)_{marg} षट्प्रदेशाः V₁ 7 हिमाद्रिः] हिमाद्रि(ः)_{supl} V₁, हिमाद्रि V₅ 8 कूटो] corrected from कूये to कूटो B₂ निषध] निषध M₁ **Verse 45** numbered 44 B₃R₃, numbered 46 V₅ on f. 28r V₁ 9 सिद्धा] z द्वा B₂ भिधा] corrected from भिधो to भिधा O त्पत्तन] त्पतन M₁, त्पंतन V₂ 10 सच्छृङ्ग] त्यच्छृङ्ग M₁, सच्छृङ्ग Ron, सच्छृङ्ग V₅ वाञ्छुक्क] वाछुक्क M₁M₂, वान्(शु)_{marg} क V₂ गिरिः] गिरिः R₁ सुनीलः] सु[f]न(र्)लः O 11 दैर्घ्येण] दैर्घ्येण R₁, दैर्घ्येण V₅ सिन्धु] सिन्धु M₁ लग्ना] लग्न M₁M₂ 12 स्तदन्तरे] स्त z तरे B₂, स्यादंतरे V₁ वर्ष] वर्य B₃ निवेश] निवेश V₅ एवम्] एव B₂

लङ्काहिमाद्वन्तरदेशवर्ति
स्याद्भारतं किन्नरवर्षमस्मात् ।
आहेमकूटं निषधावधीत्थं
बुधैः प्रदिष्टं हरिवर्षसञ्ज्ञम् ॥ ४६ ॥

सिद्धपुरोत्तरतो ऽपि तथैव
स्तः कुरुवर्षहिरण्मयवर्षे ।
।रम्यकवर्षमतश्च षडेवं
त्रीण्यपराण्यथ तानि च वक्ष्ये ॥ ४७ ॥

।माल्यवन्नग उदग्यमकोटे-
गन्धमादनगिरिस्तु रोमकात् ।
नीलसन्निषधशैलसङ्गता-
वन्तरं गिरिचतुष्टयस्य यत् ॥ ४८ ॥

5

f. 4v R₃, f. 8v V₂

f. 3v V₅, f. 5v B₃

10

Verse 46 numbered 45 B₃, numbered 44 R₃, numbered 43 V₂, numbered 47 V₅ on f. 28r V₁ 1 हिमाद्वन्तर] हिमाद्वन्त दे^३ र^१ श M₂, marked but marginalia missing due to copying error R₁, हिमाद्वन्तर V₅ देशवर्ति] मध्यवर्त्ति R₁ 2 स्याद्भारतं] स्याद्भा zz B₂, स्या [x]द्भारतं V₁, तद्भारतं V₂ किन्नरवर्ष] किन्न zz ष B₂, किन्नरवर्ष R₁V₅ मस्मात्] म z त B₂, भस्मात् R₁ 3 कूटं] कूट R₁ वधीत्थं] वधी [x](त्थं)_{marg,s} B₃, वधीत्थं? R₃, वध्त्तं? V₅ 4 बुधैः] बुधैः M₁ प्रदिष्टं] प्रतिष्टं O, प्रदिष्ट R₁ हरि] हंरि V₅ **Verse 47** numbered 46 B₃R₃, numbered 44 V₂, numbered 48 V₅ on f. 28v V₁ 5 सिद्ध] z द्व B₂ उत्तरतो ऽपि] illegible due to copying process B₂ 6 कुरु] कूर O वर्ष] om. M₁ हिरण्मय] (हि)_{marg}ण्मय B₂ वर्षे] व z B₃ 7 षडेवं] षडेव B₃, षडेव M₁, षडेवं M₂, षडिवं V₅ 8 पराण्यथ] प zzz B₂, पराणि च M₁, corrected from पिराणि थ to पराण्यथ V₂, थ V₅ वक्ष्ये] om. M₁ **Verse 48** numbered 47 B₃R₃, numbered 45 V₂, numbered 49 V₅ on f. 29r V₁ 9 माल्यवन्नग] corrected from माल्यवन्नग to माल्यवान्नग R₁, माल्यव [xx](न्न)_{marg}ग O, माल्यवन्नग R₁, माल्यवान्नग V₁ ग्यम] ग्रा^२म R₁ 10 रोमकात्] रोमका z B₂ 11 सङ्गता] सगता R₁ 12 वन्तरं] वंमरं R₁ चतुष्ट] च z ट B₂

इलावृतं वर्षमितीरितं त-
 त्सद्रत्नचामीकरचारुभूमि ।
 मध्ये ऽस्य मेरुः कमलानुकारो
 विष्कम्भशैलैः परितो वृतो ऽस्ति ॥ ४९ ॥

स्वर्णसन्मणिमयः सुरालयो
 भिन्नभूमिरुभयत्र निर्गतः ।
 मस्तके दिविषदो ऽस्य रमन्ते
 तत्तले ऽसुरकुलं निराकुलम् ॥ ५० ॥

चञ्चत्सुवर्णमणिपूर्णमनेकवर्णं
 सानुत्रयं सुरगिरौ त्रिपुरं च तेषु ।
 नित्यं रमेशपरमेशसुवर्णगर्भा-
 स्तेषामधो । ऽष्ट सुरदिक्पतिपत्तनानि ॥ ५१ ॥

5

f. 15r M₂

10

p. 11 R₁

Verse 49 numbered 48 B₃R₃, numbered 46 V₂, numbered 50 V₅ on f. 29r V₁
 1 इला] इ[x](ला)_{supl} V₁ रितं त] zz त B₂, रितं य M₁M₂R₁V₁V₅ 2 त्सद्रत्न] त्सद्र[x](त्न)_{marg} O
 चामीकर] वामीकर M₁M₂, inserted in margin but marginalia only partially visible in copy R₁
 भूमि] (भू)_{marg} मि B₂, भूमिः V₅ 3 मध्ये] corrected from मधे to मध्ये V₁ मेरुः] मेरु M₂ कमला]
 कमला M₁M₂ 4 शैलैः] शैलेः V₅ परितो] परि M₂ वृतो] वृ z B₂, धृतो V₁ ऽस्ति] स्मिन् V₅
Verse 50 numbered 49 B₃R₃, numbered 47 V₂, numbered 51 V₅ on f. 29v V₁
 5 स्वर्णसन्मणि] रत्नकांचन V₂V₅ सुरालयो] सुरालया M₁M₂, corrected from सुरालोयो to सुरालयो
 O 7 दिविषदो ऽस्य रमन्ते] marked and the variant reading सुरगणो ऽस्य दीव्यति (where दीव्यति is
 again marked and the variant reading नंदतां is given in the margin) given in the margin R₃
 दिविषदो] दिविसदो R₁V₂V₅ रमन्ते] [x] रमंते O 8 तत्तले] तेत्तले V₅ ऽसुर] (ऽ)_{supl} सुर V₂
 कुलं नि] कुलं नि R₃ **Verse 51** numbered 50 B₃R₃, numbered 48 V₂, numbered 52 V₅
 on f. 29v V₁ 9 त्सुवर्ण] corrected from त्सुवर्णं to सुवर्ण M₁ मणि] माणि R₁, परि V₁ वर्ण] वर्ण
 M₁M₂, रत्न V₅ 10 सानु] सोनु M₁M₂ गिरौ] corrected from गुरौ to गिरौ B₂, गुरौ B₃R₃V₅,
 गिरौ V₁ त्रिपुरं] भिपुरं V₁ 11 रमेश] रमंश M₁M₂ 12 मधो] corrected from मधे to मधो V₁
 सुर] सुरं V₅ दिक्पति] दिक्प्रति M₁

यन्माल्यगिर्यवधिसद्यमकोटिपुर्या
भद्राश्ववर्षमिति रोमकपत्तनाच्च ।
आगन्धमादननगं किल केतुमालं
वर्षं न वेति कथितानि पुराणविद्धिः ॥ ५२ ॥

f. 9r V₂

मन्दराचलसुगन्धपर्वतौ
पूर्वदक्षिणविभागयोः स्थितौ ।
यौ सुपार्श्वविपुलाचलौ तु ता-
वुत्तरापरदिशोः सुरालयात् ॥ ५३ ॥

5

सत्केतवो गिरिशिरःसु कदम्बवृक्षो
जम्बू सुपिप्पलवटौ च यथा क्रमेण ।
वैभ्राजकं धृतिवनं त्वथ नन्दनं च
वेद्यानि चैत्ररथमुत्क्रमतो वनानि ॥ ५४ ॥

10

f. 6v B₂

f. 6r B₃

Verse 52 numbered 51 B₃R₃, numbered 49 V₂, numbered 53 V₅ on f. 30r V₁
1 यन्मा] य[x]न्मा B₂ गिर्यवधि] गि वे र्थ धि M₁ 1-2 पुर्या भ] पुर्या भ M₁, corrected
from पुर्यभि to पुर्या भ V₁ 2 पत्तनाच्च] पत्तनांत V₅ 3 मादन] माद[त] O नगं] मिदं V₂
4 न वेति] तवेति M₁, न वेति V₁ कथितानि] z दितानि B₂, गदितानि O, corrected from काथितानि
to कथितानि V₁ पुराणविद्धिः] पूराणविद्धिः O, पुराणवद्धिः R₁, पु(रा) marg₈णविद्धिः V₂ **Verse 53**
numbered 52 B₃R₃, numbered 50 V₂, numbered 54 V₅ on f. 30r V₁ 5 मन्दराचल]
मंदारालाच M₁, मंदरालच M₂ सुगन्ध] सुगंध V₂ 6 विभागयोः] विभागयो M₁M₂R₁, विभागयो (:)^{supl}
V₁ 7 यौ] [यो] यौ B₂, पौ R₁ सुपार्श्व] शुपार्श्व R₁ 8 वुत्तरा] वुत्तराः M₁, कु[?]त्तरा V₅
दिशोः] दिशो (:)^{supl} B₃, दिशो V₁ **Verse 54** numbered 53 B₃R₃, numbered 51 V₂,
numbered 55 V₅ on f. 31v V₁ 9 सत्केतवो गि] unclear due to copying process B₂,
सत्केतको गि M₁M₂ शिरःसु] शिरस्यु M₂ वृक्षो] वृत्ते[?] B₂, [x]वृक्षो V₂ 10 जम्बू] जंबूः M₁M₂
सुपिप्पल] सुपिप्पल [xx] B₂, सु[रि]पिप्पल O, सपिप्पल V₅ यथा] तथा M₁M₂V₅ 11 वैभ्राजकं] वैभ्राजनं
M₁M₂, वैभ्राजिकं R₁V₂, वैभ्राजिकं R₃ त्वथ नन्दनं] दनं R₁ 12 वेद्यानि] ज्ञेयानि V₂ रथ] रथ[?]
V₅ मुत्क्रमतो] marked and the annotation उत्तरपश्चि[?]मदक्षिणपूर्वदि[?]कसु[?] वन[?]मि[?]त्यर्थः[?] B₂, मुत्क्रमतो V₅
वनानि] वना[दि]नि O

गिरिवनेषु सरांस्यरुणाभिधं
तदनु मानसनाम महाह्रदम् ।
सितजलाह्वयमम्बुजमङ्गलं
सजलकेलिमरालकुलाकुलम् ॥ ५५ ॥

चलदलिकुलवत्सुनीलनेत्राः
सुकनकपङ्कजकान्तवृत्तवक्त्राः ।
मदनसदनकाननेषु रामाः
सरसि वसन्त्यमरैः सहातिरम्याः ॥ ५६ ॥

5

f. 5r R₃

तज्जम्बूफलविगलज्जलप्रवाहा -
ज्जम्बूनद्यभवदियं मृदायुता सा ।
स्याज्जाम्बू।नदमिति यत्सुवर्णसज्जं
द्वीपो ऽयं निगदितवृक्षरम्यनामा ॥ ५७ ॥

f. 9v V₂

10

p. 12 R₁

Verse 55 numbered 54 B₃R₃, numbered 52 V₂, numbered 56 V₅ on f. 32r V₁
1 वनेषु] वनेषु V₅ सरांस्यरुणा] स[x]रांस्य(रु)^{supl}णा B₂, सरांस्यरुणा R₁, corrected from सुरांस्यरुणा
to सरांस्यरुणा V₁ मिधं] मिधं V₁ 2 तदनु] वदनु V₅, तनु V₅ मानस] मानस[r] O नाम]
मे[r] ना M₁, मानाम V₅ महाह्रदम्] म w ह्रदं B₂, महाह्रदं M₁, हाह्रदं M₂, महाह्रदं R₁V₅, महाह्रदं[r]
V₁ 3 जला] ज[x]शु(ला)_{marg} O ह्वय] [x](ह्व)_{marg}य B₂ म्बुज] मंबु(ज)_{marg} V₂
मङ्गलं] मंग[x](लं)_{marg} B₂, मंगल V₁ 4 सजल] सकल M₁M₂, सुजल R₃V₂V₅ कुलाकुलम्] कुलाकुली
M₁, कूलाकूलं O **Verse 56** numbered 55 B₃R₃, numbered 53 V₂, numbered 57 V₅
on f. 32r V₁ 5 चल] चल R₃ नील] w ल B₂, नीलनील V₅ नेत्राः] corrected from नोत्राः
to नेत्राः B₂, नेत्रा M₁M₂, नेत्राः V₅ 6 वृत्त] वृत्त M₁ वक्त्राः] चक्राः M₁M₂ 7 सदनकाननेषु]
स[xx](दनका)_{marg} ननेषु B₂ रामाः] (रा)_{marg}माः B₂, corrected from रामः to रामाः B₃ 8 सरसि]
सरसि V₅ वसन्त्य] च संत्य M₁M₂, corrected from वसंत्यं to वसंत्य V₁, रमत्यमरैः V₅ रम्याः]
corrected from रंभ्यां to रंभ्याः M₁ **Verse 57** numbered 56 B₃R₃, numbered 54 V₂,
numbered 58 V₅ on f. 32v V₁ 9 तज्जम्बू] तज्जुं?बू B₂ फल] जल R₁ ज्जल] om. V₅
10 ज्जम्बू] जंबू R₁ मृदायुता सा] मृदायुता सा R₃, corrected from मृदीयुता सा to मृदायुता सा V₁, सदायुता
स्यात् V₅ 11 स्याज्जाम्बू] स्याज्जुं?बू V₂, स्याज्जंबू M₁R₁ सज्जं] सं(जं)_{marg,s} B₃, सजं O, संज V₁
12 द्वीपो ऽयं] द्वीपायं M₁ निगदित] गदित M₁ वृक्ष] वक्ष V₅ नामा] नाम्ना B₂

मन्दाकिनी गगनतः पतिता सुमेरौ
विष्कम्भशैलशिखरस्थसरःसमेता ।
भद्राश्वकेतुकुरुभारतवर्षयाता
कैवल्यदा कलियुगे ऽपि निमज्जतां सा ॥ ५८ ॥

f. 6v O & f. 10r g V₂

खण्डान्यथैन्द्रं च कशेरुताम्र-
पर्णे गभस्त्याख्यकुमारिकाख्ये ।
सौम्यं च नागाभिधवारुणे च
गान्धर्वसज्ज्ञं त्विति भारतान्तः ॥ ५९ ॥

5

Verse 58 numbered 57 B₃R₃, numbered 57 V₂, numbered 59 V₅ on f. 32v V₁ placed between a verse unique to V₂ and verse 61 on f. 10r V₂ 1 गगनतः] गगन[x]तः B₂, गगनता M₁, गगनतां M₂ सुमेरौ] सुमेरौ B₂ 2 शिखरस्थसरः] शिखरस्थशिसरः B₃R₃, corrected from सिखरस्थसरः to शिखरस्थसरः O, शि[xxxx](खरस्थसरः)_{marg,s} V₁, शिखरम्यसरः V₅ समेता] समे z B₃, समेताः V₅ 3 केतु] के[x](तु)_{marg,s} O कुरु] कुनु V₁ याता] पाता B₃R₃, जाता R₁ 4 कैवल्यदा] कैमुक्तिदा B₃, कैवल्यदा R₃ निमज्जतां सा] corrected from निमजातां सा to निमज्जुं? सा B₂, corrected from निमज्जता सां to निमज्जता सा M₁, निम[f]ज्जतां सा M₂ **Verse 59** numbered 58 B₃R₃, numbered 55 V₂, numbered 60 V₅ on f. 33r V₁ placed between verse 58 and verse 60 on f. 9v V₂ 5 थैन्द्रं] थेंद्रं R₁M₁M₂V₁, थेंद्रं OV₅ कशेरु] कसेर B₂, कसेरु R₁R₃V₁, कसेरु V₅ 6 पर्णे] पण्णों R₁ कुमारिका] कुमारि(का)_{marg} B₂ 7 सौम्यं च] सुमेरु B₃R₃ वारुणे च] वारुणानि B₃R₃, वारुणं च R₁ 8 गान्धर्व] गंधार्व B₂, गान्धर्व where ध is inserted into the line by s O त्विति] त्वित? V₅ तान्तः] तां(तः)_{marg} O

माहेन्द्राह्वयशुक्तिसञ्ज्ञमलयास्ते भारते पर्वताः
 प्रोक्ता ऋक्षकपारियात्रकगिरी सह्यश्च विन्ध्यस्ततः ।
 ।उद्दिष्टं क्षितिपृष्ठनिष्ठमखिलं खण्डं प्रचण्डाचल -
 ग्रामा।रामसरःपुरःसरमतः पातालतः कथ्यते ॥ ६० ॥

f. 4r V₅

f. 33v V₁

भू।सम्पुटे सप्त पुटानि गर्भे
 तानीह पातालसमाह्वयानि ।
 एतेषु नागेन्द्रफणामणीन -
 प्रकाशतः पश्यति नागलोकः ॥ ६१ ॥

5 f. 6v B₃

Verse 60 numbered 59 B₃R₃, numbered 57 V₂, numbered 61 V₅ on f. 33v V₁ placed between verse 59 and a verse unique to V₂ on f. 9v V₂ before the verse इह सप्त कुलाचलास्युरेतो मा (compare unique verse in V₂ given at the end of the apparatus of this verse) V₅ 1 माहेन्द्राह्वय] माहे(द्रा)_{marg}ह्वय B₃, माहेद्रा[x](ह्व)_{marg}य O शुक्ति] मुक्ति B₂, x क्ति O मलया] [x]मलया[x] O स्ते भारते] z भारते B₃, स्तद्भारते M₁, स्तद्भारते M₂R₁V₁V₂V₅, corrected from स्ते x रते to स्त[x](द्वा)_{marg}रते O, स्तद्भारते marked and the annotation कन्याख्यखंडे नगा added in the margin R₃ 2 प्रोक्ता ऋक्षकपा] प्रोक्ता(:)_{supl} [त्]सक्षकपा B₂, w क्ता ऋक्षकपा B₃, प्रोक्ताक्षकपा M₁M₂, प्रोक्तात्सक्षक R₃, प्रोक्ता: [x]क्षकपा[x] V₂ कगिरी] इतर B₂, कगिरी M₁M₂, इतरतः R₁, इतर: R₃V₁V₂ सह्यश्च] सह्यश्च M₁M₂, (स)_{marg}ह्यश्च O, सह्य: स V₅ विन्ध्य] विन्ध्य M₂, विन्ध्यं V₁, विन्ध्य V₅ 3 निष्ठ] om. but there is an insert though the marginalia is destroyed B₂ मखिलं] निखिलं R₁ खण्डं] खण्ड B₂B₃M₁M₂, खण्ड[प्र]खण्ड R₁ चल] खिल R₁ 4 सर:] सरे: V₅ after verse 60 is a verse numbered 56 इह सप्त कुलाचला: स्युरेतो माहेन्द्रक्ष[x]कशुक्तिसह्यविन्ध्या: । मलयाचलपारियात्रकाख्यौ वर्णा विप्रमुखा: कुमारिकाख्ये V₂ **Verse 61** numbered 60 B₃R₃, numbered 58 V₂, numbered 62 V₅ on f. 33v V₁ placed between verse 58 and verse 62 on f. 10r V₂ 5 सप्त] सप्त M₁M₂ 6 पाताल] याताल R₃ समाह्वयानि] after समाह्वयानि are about 12 erased *akṣaras* B₃, समा[x](z)_{marg}पानि O 7 कणा] कणी R₁ मणीन] corrected from मणीन to मणीनां B₃, corrected from मणीने to मणीन O, मणीनं V₁, मणीनां V₅ 8 पश्यति] पश्यतु R₁

अतलं वितलं तलं निपूर्वं
तदधो ऽन्यच्च गभस्तिमन्निरुक्तम् ।
अपरे ऽपि महासुपूर्वके ते
किल पातालतलं तु सप्तमं यत् ॥ ६२ ॥

।पाताले।ष्वसितासितारुणनिभा पीताधरा शर्करा
शैलाभा कनकोत्तमाधरतले पृथ्वीधरो ऽयं फनी ।
पादाक्रान्तमहीतले हि कमठे तिष्ठन्कदाचिद्धरा-
भारानम्रशिरास्तदा कुचलनं स्यात्संहितासम्मतम् ॥ ६३ ॥

5 f. 7r O, f. 7r B₂

।भूमेर्द्वादशयोजनेषु वसते भूवायुरत्राम्बुदा-
स्त।स्मादावहसञ्ज्ञकः प्रवह इत्यस्मात्स पञ्चाङ्गतिः ।
तस्मादुद्धहसंवहौ परिपरापूर्वौ वहौ तत्परा-
वेतेषु प्रवहानिलेन पव।ते तारागणः सग्रहः ॥ ६४ ॥

f. 10v V₂

10 f. 34v V₁

f. 5v R₃

Verse 62 numbered 61 B₃R₃, numbered 59 V₂, numbered 63 V₅ on f. 33v V₁ 1-4 निपूर्वं—तलं] om. but added in margin without variants from the given text R₃
1 निपूर्वं] zz वै B₂ 2 तदधो ऽन्यच्च] दधोषच्च R₁ गभस्ति] गगस्ति M₂, गभ[र]स्ति V₁ मन्निरुक्तम्]
मं निरुक्ते M₁M₂ 3 ऽपि] तु M₁M₂V₂V₅ पूर्वके ते] पूर्वके ति B₃, पूर्वकेस्ते: M₁M₂, पूर्वके तौ R₁
4 सप्तमं] सप्तमं V₅ **Verse 63** numbered 62 B₃R₃, numbered 60 V₂, numbered 64 V₅
on f. 33v V₁ 5 पातालेष्व] पाताले [f]ष्व V₃ सितारुण] सि(ता)_{marg} रुण B₂, सिते रुण M₁M₂
निभा] निभा: M₁M₂ धरा] धरा: M₁, सिता R₁ शर्करा] शर्करा: V₅ 6 भा] भा(:)_{subl} M₁, भा: M₂
धरतले] धरते R₁ 7 पादा] पादां B₃R₃, पाता M₁M₂ महीतले] मही(त)_{supl,s} ले V₅ हि] दि B₃R₃,
ही O कमठे] क[र]मठे O, corrected from कमठे to कमठे V₁, मकठे V₅ तिष्ठन्कदा] तिष्ठन्कदा B₃R₃,
तिष्ठन्कदा M₁, तिष्ठत्कदा V₅ चिद्धरा] चिधरा V₂ 8 नम्र] निम्र M₁M₂ शिरास्तदा] corrected
from शिरस्तदा to शिरास्तदा V₁ कुचलनं] कुचल[x]नं V₂, कुलचलं [x] V₅ सम्मतम्] संमते B₃R₃
Verse 64 numbered 63 B₃R₃, numbered 62 V₂, numbered 65 V₅ on f. 34r-34v V₁
9 द्वादश] corrected from द्वादश to द्वादश B₃, द्वादशर B₃, द्वादश M₁M₂, द्वां [दि]श O, द्वदिशर R₃
योजनेषु] योजनेषु M₁ वसते] corrected from वसते to वसते B₃, वसते R₃, च सते V₁ रत्राम्बु]
corrected from रत्रांबु to रत्रांबु B₃, रत्रांबु R₁ 10 दावह] दाहव OV₂ सञ्ज्ञकः] संज्ञकश्च R₁, संज्ञक R₃
11 दुद्धह] दु x (दु)_{supl}ह V₁, दुद्धर V₅ संवहौ] सवहौ R₃ पूर्वौ वहौ] पूर्वा z रौ B₃, पूर्वौ विहौ M₁M₂,
पूर्वापहौ R₁, पूर्वापरी R₃, पूर्वाविहौ V₁, [xx]पूर्वावहौ V₂, पूर्वावहौ V₅ 12 वेतेषु] वे [तो]तेषु B₂, वेतैषु R₃
प्रवहा] प्रवाहा O, corrected from प्रवहो to प्रवहा V₁ निलेन पवते] निलेन[?] पवने[?] B₂, निलेन प्र[?]वते M₁,
निलेनृपंतते V₅ तारा] रतारा O सग्रहः] om. but added in margin O

वियति मेरुशिरस्तलयोर्ध्रुवौ
भवलयं भ्रमति ध्रुवमध्यगम् ।
खगतचुम्बकनामदृषद्वया -
न्तरगतायसवन्न पतत्यधः ॥ ६५ ॥

भूगर्भतो रसरसेषुमहीषु ५१५६६ सङ्घौः
शीतांशुमण्डलमलं जलगोलरूपम् ।
दन्ताभ्रषणनृप १६६०३२ मितैः शशिजं कविं तु
तेजोमयं गजगजाम्बरसिद्धवेदैः ४२४०।८८ ॥ ६६ ॥

5 f. 15v M₂

f. 7r B₃

f. 35v V₁

उष्णद्युतिं नगनगानलानन्दनाग -
तर्कैः ६८९३।७७ कुजं नवकुषड्रसरन्ध्रसूर्यैः १२९६६१९ ।
जीवं गजत्रिशरऋत्वगभूमिनागै - ८१७६५३८
।मन्दं धरादिनवतीन्दुगुणाभ्रनेत्रैः २०३१९०७१ ॥ ६७ ॥

f. 7v O

10 p. 14 R₁

f. 11r V₂

Verse 65 numbered 64 B₃R₃, numbered 63 V₂, numbered 66 V₅ on f. 35r V₁
1 मेरु] मेरुमि O, मे(रु)_{marg} V₁ शिर] (f)शर V₁ स्तलयोर्ध्रु] स्तलयो zz B₂, स्तलयो ध्रु
ल R₁, स्तलयोर्ध्रु V₁, स्तलयो ध्रु V₅ 2 ध्रुव] ध्रुव B₂ मध्यगम्] मध्यमगं O 3 खगत] खगत M₂
चुम्बक] पुंवक V₅ 3-4 दृषद्वयान्तर] दृषद्वयान्तर B₂, दृषद्वयान्तर M₁M₂R₁V₂, दृषद्वयान्तर V₁, दृषद्वयान्तर V₅
4 गतायसवन्न] गतापसवन्न R₁, गतापसवन्न[?] V₁, गताद्वयसन्न V₅ पतत्यधः] पत[x]त्यधः O, पतत्ययः V₁
Verse 66 numbered 65 B₃R₃, numbered 63 V₂, numbered 66 V₅ on f. 35r-35v V₁
5 भूगर्भतो] marked and the annotation एते मध्यकर्णा ब्रह्मसिद्धांतोक्ता ज्ञेयाः added in the margin
५१५६६] placed after सङ्घौः B₂M₁M₂V₁V₂V₅, ५१६६ placed after सङ्घौः O सङ्घौः] संख्यै OR₁V₅
6 मण्डल] मं ले डं M₂ 7 दन्ता] marked and the annotation वेधा धारयामास संति[?] सर्वत्र संध्य[?]ध्यते
added in the margin (seems to belong rather to verse 68) B₂ १६६०३२] placed after मितैः
B₂B₃M₁M₂R₃V₂V₅, १६६१३२ O, १६६०३९[?] placed after मितैः V₁ मितैः] मितै(:)_{supl} B₃, मितै
OR₃V₅, मित R₁ 8 मयं] मयां M₁M₂, मय R₁, (म)_{subl}यं V₁ गज] corrected from गम
to गज M₁ **Verse 67** numbered 66 B₃R₃, numbered 64 V₂ on f. 35v V₁
9 द्युतिं न] corrected from द्युतिर्न to द्युतिं न B₃ नगा] नगा marked and गा added in the margin
to make the reading clear R₁ नल] नाल R₁ 9-10 नन्दनागतर्कैः] लनंदनागतर्कैः but the the
top of the *akṣaras* are cut due to copying process so reading uncertain O 10 कुजं] कुजे R₁
नव] न M₂ सूर्यैः] सूर्यै O १२९६६१९] १२९६१९ V₅ 11 त्रिशरऋत्व] illegible due to copying
process B₂, त्रिशर[x](ऋ)_{marg,s}त्व B₃ भूमि] सूमि M₂ नागै] नागैः R₁V₁ ८१७६५३८]
८१७६ (w)_{marg}३८ V₂ 12 नव] नव[x] O गुणाभ्र] गुणा[x](भ्र)_{marg,s} B₃ नेत्रैः] नैत्रैः V₅
२०३१९०७१] unclear due to copying process B₂, २०३१९०७१ O

।वसुशररसनेत्राङ्गाग्निभूवेद ४१३६२६५८ सङ्घौ -
 विर्यति सकलदूरे मण्डलं तारकाणाम् ।
 सममुडुभिरदृश्यैरङ्कितं दस्रभाद्यै -
 ध्रुवयुगपरिबद्धं धारयामास धाता ॥ ६८ ॥

f. 7v B₂

अत्र भास्करपृथूदकमुख्यै -
 वासना न कथिता निजतन्त्रे ।
 तां विरोधिमतदूषणदक्षां
 वच्मि सन्मतिमतामतिरम्याम् ॥ ६९ ॥

5

स्वक्ष्माजेन्दुसमुद्रमास्तमययोः कालान्तरं यद्भवे -
 तत्स्वीयं दिनमानमम्बुघटिकायन्त्रेण संसाधितम् ।
 यत्त्वत्रैव दिने निशाकरचरात्तिप्रश्नमार्गेण त -
 द्भूगर्भस्थनरद्युमानमनयोर्नाड्यन्तरेणेति चेत् ॥ ७० ॥

10

Verse 68 numbered 67 B₃R₃, numbered 65 V₂ on f. 35v V₁ 1 रस] वसु B₂OV₅ ४१३६२६५८] ४१३६(२८)_{marg} ५८ at the end of the *pāda* B₂, placed at the end of the *pāda* B₃M₁M₂OR₁R₃V₁, placed after विर्यति in the next *pāda* V₁, ४१३६५८ at the end of the *pāda* with ४१३६२८५८ added in the margin by s V₅ सङ्घौ] सं[र]ख्ये O 2 सकल] सवल V₅ तारकाणाम्] तारकानां R₁ 3 दृश्यै] z श्यै B₂ 3-4 भाद्यैध्रु] भाद्यै ध्रुव M₁ 4 बद्ध] corrected from बद्ध to बद्ध V₁ धाता] वेधा B₂B₃R₃, वेधा: M₁M₂OV₂, वेद्या R₁ **Verse 69** numbered 68 B₃R₃, numbered 66 V₂ on f. 36v V₁ at the beginning of the verse is added अत्रोपपत्ति: in the margin by s B₃ 5 पृथू] प्रथू R₁ दक] corrected from कक to दक B₃, कक R₃ 6 न कथिता] न गदिता B₂B₃OR₃, निगदिता M₁M₂ तन्त्रे] तन्त्रे V₅ 7 विरोधि] विसेधि R₃ मतदूषण] म(त)_{marg} x षण M₁ 8 मतामतिरम्याम्] (मतामति)_{marg} रम्यां B₂, मतामतिरभ्यां M₁, मतामपि रम्यां V₂, मतामतिरम्यं V₅ **Verse 70** numbered 69 B₃R₃, numbered 67 V₂ on f. 37r V₁ 9 स्वक्ष्माजे] marked and the annotation भूपृष्टक्षितिजे added in the margin by s B₃ समुद्रमा] समु[x](द्र)_{marg,s} मा O मययो:] मययो R₁R₃ यद्भवे] corrected from यद्भवे to यद्भवे V₁ 10 मम्बु] corrected from म्बु to म्बु O संसाधितम्] ससाधितं R₁ 11 यत्त्वत्रैव] corrected from यत्त्वत्रैव to यत्त्वत्रैव B₂, यत्त्वत्रैव M₂V₅, य[x](त्व)_{marg} त्रैव O, यत्त्वत्रैव R₁ निशा] (नि)_{marg} शा B₂ करचरात्ति] करचरा त्रि M₁OR₁, चरकरा त्रि M₂ प्रश्न] प्र[x](श्न)_{marg,s} O, प्रदम R₁, श्र V₁ मार्गेण] मार्गेण V₅ 12 द्भू] द्भू R₁ नयोर्ना] नयो ना M₁V₅ रेणेति चेत्] corrected from रेणैति चेत् to रेणेति चेत् B₂, रेणैव चेत् B₃R₃, रेनैव चेत् R₁, रेणैति चेत् V₁V₅, corrected from रेणैति चेत् to रेणेति चेत् V₂

इन्दुद्विसङ्गुणमहीदलयो | जनानि
स्वीयद्वुरात्रघटिकाभिरियं तदा किं ।
त्रैराशिकेन विधुयोजनकक्षि | केति
वा सूर्यपर्वत इयं परिसाधनीया ॥ ७१ ॥

f. 11v V₂

चेत्स्पष्टगत्या | विधुकक्षिकेयं
तन्मध्यगत्या किमितीह | मध्या ।
तच्चन्द्रचक्राभिहतिः स्वकक्षा
सा खेटचक्रैर्विहता स्वकक्षा ॥ ७२ ॥

5 f. 7v B₃

p. 15 R₁, f. 6r R₃

Verse 71 numbered 70 B₃R₃, numbered 68 V₂ on f. 37r V₁ 1 इन्दुद्वि] इं x द्वि B₃, इन्दुद्वि M₁R₁V₁V₂, corrected from इन्दुद्वि to इन्दुद्वि O द्विसङ्गुणमहीदल] marked and the annotation समग्रभूव्यासयोजना १५८१ नीत्यर्थः added in the margin B₂ सङ्गुण] corrected from सुगुण to संगुण V₁, सं[x]गुण V₅ योजनानि] योजनानि O 2 स्वीयद्वु] स्युयद्वि M₁M₂, स्वीय[द्यु]मानमनयोनां द्यु O रात्र] रात्रि R₁V₂V₅ घटिकाभि] घटिका(भि)_{marg} B₂, घटिकाभि R₁ रियं] रयं B₃R₃V₂ तदा किं] तदार्कि B₃M₂ 3 केन] केण B₂B₃M₁M₂R₃V₂V₅, न marked (perhaps to signify that the wrong sibilant is used) V₁ कक्षिकेति] कक्षकेति V₂ 4 वा] (वा)_{marg} B₂ सूर्यपर्वत] marked but marginalia illegible due to copying process B₂, corrected from पर्वत to पर्वत V₁, पर्वत V₅ इयं] नयं V₅ नीया] नीयाः R₁ **Verse 72** numbered 71 B₃R₃, numbered 69 V₂ on f. 38v V₁ 5 विधु] विधू R₃ कक्षिकेयं] कक्षकेयं M₁M₂OV₁V₂ 6 तन्मध्यगत्या किमितीह मध्या] तन्मध्यया केति फलं स्वकक्षा V₂ किमितीह] किमि[f]त(र्)ह O, कियतीह R₁, corrected from किमितीहु to किमितीह V₁ 7 चक्रा] कक्षा B₃M₁M₂R₁R₃ भिहतिः] भिह[र्]तिः B₃, भिहति R₁, भिहतिः R₃, भिहतः V₅ 8 सा खेटचक्रै] marked and the annotation ग्रहभगणैः added in the margin by s B₃ सा खेट] खेटस्य B₂OV₅, खेट - M₁, खेट - M₂, मा खेट V₁ चक्रै] चक्रै M₁ विहता] वि[f]हता V₂ कक्षा] कक्षया M₁M₂, कक्षाः V₅

त्रिज्यागुणा भगणभागकलाविभक्ताः
 कक्षाः स्वयोजनमयाः । श्रवणा भवन्ति ।
 व्यासः पदं परिधिवर्गदशाहतेः स्या-
 त्स्थूलः स्फुटस्त्रिभगुणो द्विगुणो भवृत्ते ॥ ७३ ॥

f. 11v M₁

पूर्णपूर्णखयुगाङ्गमङ्गला -
 शीतिविंशतिधरागवस्विलाः १८७१२०८०८६४००० ।
 खेटयोजनगतिर्युगे ऽखिला
 गोऽक्षखाक्ष ५०५९ वलया भवेदिला ॥ ७४ ॥

5

इति सद्वासनाज्ञात -
 योजनश्रुतयः स्मृताः ।
 धरापरिधिमानं च
 वासनागमसम्मतम् ॥ ७५ ॥

f. 8v O

10

f. 8r B₂

Verse 73 numbered 72 B₃R₃, numbered 70 V₂ on f. 40r V₁ 1 त्रिज्या] त्रिज्या
 ३४३७ V₁ गुणा] गुणा (:) ^{supl} B₂, गुण M₁, गुण M₂ भगण] भगणः M₁, भगन R₁ भाग] भाग ^{२१६००} B₃,
 भा (ग) ^{marg} O, marked and २१६०० added in the margin R₃, भाग २१६०० V₅ विभक्ताः] विभ २१६००
 क्ताः V₂ 2 कक्षाः] कक्षा M₁R₁V₅, कक्ष्या V₁ मयाः] मया M₂R₁V₅, मय V₁V₂ श्रवणा भवन्ति]
 श्रवणाः स्युरेवं V₂ 3 व्यासः] व्यास (:) ^{subl} M₂ परिधि] परिधि M₁ 3-4 दशाहतेः स्यात्स्थूलः]
 दशांशक [ट] स्य [r] [ट] स्थूलः V₂ 3 हतेः] ह z B₂, हते M₂R₁V₅, हते (:) ^{supl} V₁ 4 स्थूलः]
 स्थूल M₁M₂, स्थूल [x] V₁ स्फुटस्त्रि] स्फुटास्त्रि M₂, (स्फुटस्त्रि) ^{marg} V₁, स्फुटःस्त्रि V₂ भगुणो]
 marked and the annotation भगणकलाभिः २१६०० द्विगुणत्रिज्यामितो व्यासः ६८७६ तदा x परिधौ ५० । www
 added in the margin V₂ द्विगुणो] (द्विगुणा) ^{marg} (द्वि w) ^{marg} B₂ भवृत्ते] भवृत्ते O, भवन्ति V₅
Verse 74 numbered 73 B₃R₃, numbered 71 V₂ on f. 40v V₁ 5 युगाङ्ग] गुणाङ्ग B₃R₃
 गाङ्गमङ्गला] illegible due to copying process B₂ मङ्गला] द्रयासि V₅ 6 शीति] सी [x] ति with
 सी marked and शी added in the margin V₁ धराग] धरण M₁, corrected from धरण to तो
 धराग V₁, धराङ्ग V₅ वस्विलाः] वस्विला R₁, व x लाः V₅ १८७१२०८०८६४०००] om. B₂OR₁V₁V₅,
 १८७१२०८०८६३००० B₃R₃, १८७०२०८०८६४००० M₁M₂ 7 खेट] खेट [x] B₂ युगे] युगैः M₁M₂ ऽखिला]
 मता V₂ 8 ५०५९] om. B₂OR₁V₁V₅, वलया ५०५९ B₃R₃V₂ दिला] दि x (ला) ^{supl} V₁
Verse 75 numbered 74 B₃R₃, numbered 70 V₁, numbered 72 V₂ on f. 41r V₁
 9 इति] (इ) ^{marg} ति V₁ सद्वा] [f] सद्वा B₂ ज्ञात] ज्ञात V₁, ज्ञान V₅ 9-12 त—सम्मतम्] top of
 each akṣara cut off in copying process so readings uncertain O 10 योजन] योजनः M₁M₂
 श्रुतयः] श्रुतयः B₂OR₁, श्रुतय (:) ^{supl} V₁ स्मृताः] स्मृता (:) ^{supl} B₃, स्मृता R₃ 12 सम्मतम्] समतं
 R₁V₁, नमतं V₅

पौराणिकैः ।समुदिताः पृथिवीग्रहर्क्ष-
संस्थानमानगतयः परमार्थतस्ताः ।
कल्पान्तरे तु किल सम्प्रति कालबोध-
शास्त्रोदिताः सुमतिभिः परिवेदितव्याः ॥ ७६ ॥

f. 12r V₂

एवं विराट्पुरुषस्य वपुः सभेदं
यो वेद विश्वमयमाद्यमुनिप्रणीतम् ।
सायुज्यतां भगवतो लभते नितान्तं
श्रीबादरायणमुनेरिति वाक्यतो ऽर्थः ॥ ७७ ॥

5

यत्पिण्डीवल्यं स सागरधरा मे।रुः शलाका परा
कूर्मो ।मूलधरांबरालयचरा स्नानाय धाराधराः ।
पूजापुष्पफलानि भेन्दुखचरा नीराजने भास्करो
ज्योतिर्लिङ्गमजेन पूजितमिति स्वान्ते ऽस्तु मे सर्वदा ॥ ७८ ॥

p. 16 R₁

10 f. 8r B₃

Verse 76 numbered 75 B₃R₃, numbered 73 V₂ on f. 41r V₁ 1 पौराणि]
top of each *akṣara* cut off in copying process so readings uncertain O समुदिताः] समुदितां
M₁M₂OR₁V₁V₂ पृथिवी] पृथिवी O 2 तस्ताः] तस्थाः M₁, तास्ताः V₁ 3 कल्पान्तरे] marked but
marginalia mostly illegible B₂, कल्पांतरैः R₃, क z तरे V₅ तु] (तु)_{marg} V₂ 3-4 कालबोधशास्
त्रोदिताः] marked and the annotation ज्योतिःशास्त्रोदिताः added in the margin by s B₃ 3 बोध]
बोधा V₅ 4 सुमतिभिः परि] सुमतिभिः पर M₂, सुमति (भिः प)_{marg} रि V₁ तव्याः] तव्या B₃M₁M₂R₃
Verse 77 numbering illegible B₂, numbered 76 B₃R₃, not numbered R₁, numbered 74
V₂ on f. 41v V₁ 5 पुरुषस्य] पूरुषस्य O वपुः] corrected from वपुः O सभेदं] सभेद R₃
6 यो] या M₁M₂ माद्य] corrected from माद्य to माद्य O मुनि] मुनी M₂ 7 सायुज्य] सायुज्य R₁
लभते] corrected from लभते to लभते O नितान्तं] नितान्तं M₁ 8 बादरायण] बादरा [लोनेई] यण V₁
वाक्यतो] वाक्यत्ये M₁ ऽर्थः] र्थं M₂ **Verse 78** numbered 79 B₂, numbered 77 B₃R₃,
numbered 75 V₂ on f. 42r V₁ 9 यत्पिण्डी] यत्पिण्डा V₅ सागर] साग [x] र B₂ मेरुः] मेरु
B₃R₃ शलाका] शल [:] का O, शलका R₁ परा] पपरा R₃ 10 कूर्मो] कूर्मै M₁, कूर्मे M₂, कर्मो V₁
धरांबरालयचरा] धरांबरालयचरा (:?)_{supl} B₂, धरोवेरालयचरा B₃R₃, धरोंबर-ध चराः M₁, धरो ब-----थचरा
M₂, धरांबरालयचराः OR₁, धरावरालयचरा V₁, धरांबर [x] रालयचराः V₂, धरोंबरालयचराः V₅ स्नानाय]
स्नानाय B₂ धारा] धुरा M₁, धरा M₂ 11 पूजा] unclear in the copy V₅ भेन्दु] भेद M₁M₂,
भेन्दु R₃ खचरा] खचरा [xx] B₃, खरचरा V₅ नीराजने] नीराजनै B₃, नीराजते M₁M₂V₅, नीराजनै R₃
भास्करो] भस्करा B₂M₁M₂V₁V₂, भास्करा O, भास्कर V₅ 12 ज्योतिर्लिङ्ग] ज्योतिर्लिग M₁V₅ मजेन]
मनेन V₅ पूजितमिति] पूजितमदः B₃R₃, पूजितमिदं R₁

।इत्थं श्रीमन्नागनाथात्मजेन
 प्रोक्ते तन्त्रे ज्ञानराजेन रम्ये ।
 ग्रन्थागाराधारभूते प्रभूते
 गोलाध्याये लोकसंस्था निरुक्ता ॥ ७९ ॥

f. 9r O

Verse 79 numbered 80 B₂, numbered 78 B₃R₃, not numbered V₂ on f. 43r
 V₁ 1 इत्थं] इत्थं M₂ श्रीमन्नाग] श्रीमज्जाग O 1-3 न—प्रभूते] om. M₁ 2-3 प्रोक्ते—
 प्रभूते] om. M₂ 2 प्रोक्ते] प्रो [म]क्ते O तन्त्रे] corrected from तेत्रे to तंत्रे O 3 गाराधार]
 गाधाराधार V₁ प्रभूते] om. V₅ 4 गोलाध्याये] गोभाध्याये R₃ संस्था] zz B₂ निरुक्ता]
 निरुक्ता M₁M₂ **Colophon** on ff. 43r-43v V₁ इति श्रीमन्नागनाथात्मजज्ञानराजविर
 then about 13 illegible *akṣaras* धिकारः B₂, इति श्रीमन्नागनाथात्मजज्ञान (राजविरचिते)_{marg,s} सिद्धांतसुंदरे
 गोलाध्याये भुवनकोशवर्णनं नाम प्रथमाधिकारः B₃, इति सिद्धांतसुंदरे गोलाध्याये भुवनकोशाधिकारः M₁, इति सिद्धांतसुंदरे
 गोलाध्याये भुवनकोशाधिकारः M₂, इति श्रीमन्नागनाथात्मजज्ञानराजविरचिते सिद्धांतसुंदरे भुवनकोशधिकारः O, इति
 सुंदरसिद्धांते भुवनकोशः R₁, इति श्री (म)_{marg,s} न्नागनाथात्मजज्ञानराजविरचिते then about 30 erased *akṣaras*
 | (f. 6v R₃) then about 4 erased *akṣaras* सिद्धांतसुंदरे गोलाध्याये भुवनकोशवर्णनं नाम प्रथमाधिकारः
 R₃, इति श्रीमत्सकलसिद्धांतवासनाविचारचतुरप्रचुरतरपरशास्त्ररहस्याभिज्ञद्वैवज्ञज्ञानराजग्रथित सिद्धांतसुंदरवासनाभाष्ये
 सुजनविभूषणैकभूषे | (f. 43v V₁) ज्ञानराजद्वैवज्ञसूनुपंडितचिंतामणिविरचिते ग्रहगणितचिंतामणौ गोलाध्याये भुवनकोसंस्
 थानव्यावर्णनं नाम प्रथमाधिकारः V₁, इति श्रीमत्सकलसिद्धांते वासनाविचारचतु | (f. 12v) रचित्तचमत्कारिणि
 सत्तन्त्राधारे सिद्धांते सुंदरे गोलाध्याये भुवनकोशसंस्थाकथनं नाम प्रथमाधिकारः V₂, इति श्रीमत्सकलसिद्धांते
 वासनाविचारचतुरचित्तचमत्कारिणि सुतंत्रोधा'रसिद्धांतसुंदरे गोलाध्याये भुवनकोशस्थके कथनं नाम प्रथमाधिकारः V₅

〈अथ ग्रहगणिताध्याये मध्यमाधिकारः〉

दिङ्मातङ्गसुतुङ्गपञ्चवदनं विश्वैकलम्बोदरं
चूडारत्नसहस्रभूधरमहाहारं सुनीलाम्बरम् ।
स्वान्तध्वान्तहरं कलानिधिधरं कोटीनरुक्सुन्दरं ।
वाराहोपमवाहनं गणपतिं वन्दे परं शङ्करम् ॥ १ ॥

f. 32r V₂

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अथ युगैः शशिशैल ७१ मितैर्मनु-
र्विधिदिने मनवस्तु चतुर्दश १४ ।
कृतसमासम १७२८००० सन्धियुतैश्च तै-
स्त्रिसमयेषु सहस्रयुगं दिनम् ॥ २ ॥

अयुत १०००० निहतदन्तवेद ४३२०००० वर्षै-
र्युगमथ तच्चरणाः कृतादयः स्युः ।
युगगुणयुगलेन्दुभिः ४ । ३ । २ । १ पृथग्घ्ना
युगदशमांशसमाः ४३२००० समास्तु सौराः ॥ ३ ॥

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f. 12v V₅

chapter opens श्रीवरमूर्तये गजाननाय नमः B₄R₃, श्रीवरदमूर्तिर्जयति B₅, श्रीवरदमूर्तिर्जयति ॥
श्रीरघुवीरगुरुचरणकमलेभ्यो नमः I, श्रीगणेशाय नमः M₁V₄, श्रीमहागणपतये नमः M₂, श्रीगणेशाय नमः ॥ श्रीसरस्वत्यै
नमः ॥ श्रीलक्ष्मीनृसिंहाय नमः M₃, श्रीकृष्णाय नमः ॥ ॥ अथ सुंदरसिद्धांत उत्तरार्द्धं लिख्यते R₁, श्रीवरदमूर्तये नमः V₂,
श्री अभयवरदमूर्तिर्जयति V₃ Verse 1 2 सुतुङ्ग] सुतंग B₅M₃V₄ लम्बोदरं] ले[r] बोदरं V₂
3 हारं] दारं R₃ 4 स्वान्त] स्वां x B₅ स्वांतं M₂ ध्वान्त] ध्वात M₃ कोटीन] कोटीर B₄R₃, कीटीन M₂,
कोटी[f]in V₅ 5 वाहनं] वाह[x x]नं B₅ गणपतिं] गणपति R₁ Verse 2 6 युगैः] युग M₂
७१] om. B₅M₁M₃R₁V₃V₄ 7 स्तु चतुर्दश] स्तु x तु x श B₅ १४] om. B₅M₁M₃V₂V₃V₄
8 कृतसमासम] कृतसमाऽसम R₁ १७२८०००] om. B₄M₃V₂V₃V₄V₅, placed before कृत in *pāda* c R₁
9 सहस्र] सुहस्र V₄ Verse 3 not numbered R₁ 10 अयुत] अयुतं V₃ १००००]
om. B₄B₅IV₃V₅ निहतदन्त] (निहतदंत)_{marg,s} V₅ ४३२००००] om. B₅IM₃V₃V₂, ४३२ placed
after वर्षै in *pāda* a M₁M₂ ४३२००० वर्षै] व x x ३२०००० V₅ 11 युगमथ] युगमय R₃, युगमथ V₃
कृतादयः] कृतादय M₂M₃R₁ 12 युगगु] युगुण corrected to युगगु V₄ युगलेन्दुभिः ४ । ३ । २ । १ पृथग्घ्ना]
युगलेन्दुभिः ४ । ३ । २ । १ पृथग्घ्ना B₄, युगलेन्दुभिः पृथक्घ्ना B₅, युगलेन्दुभिर्विनिघ्ना IV₂, युगलेन्दुभिः ४ । ३ । २ । १ पृथक्घ्नाः
M₁, युगले भिः दु ४ । ३ । २ । १ पृथक्घ्नाः M₂, युगलेन्दुभिः पृथक्घ्ना M₃, युगलेन्दुभिः कृतघ्नाः (कृत marked by scribe,
who adds a line in the margin (broken due to flaw in photocopying) beginning with च R₁,
(यु)_{marg} युगलेन्दुभिः पृथक्घ्ना V₃, यमलेन्दुभिः ४ ११ ३ । २ १ १ पृथक्घ्ना V₄, युगलेन्दु ४ । ३ । २ । १ । भिः पृथक्घ्ना V₅
13 दशमांशसमाः] दशमांसमाः V₅ ४३२०००] om. B₄B₅IM₃R₁R₃V₂V₃V₄V₅ after the verse
number M₁ and M₂ inserts १७२८००० । १२९००० । ८६४००० । ४३२०००

याताः पितामहदिने मनवः षड् ६ स्मि-
 न्स्युः सप्तविंशति २७ युगानि युगत्रि ३ पादाः ।
 नन्दाद्रिचन्द्रदहनाः ३१७९ कलिवत्सराश्च
 सच्छालिवाहनशकप्रभवे प्रयाताः ॥ ४ ॥

प्रागुक्तसृष्टिशरदः ४७४०० खरसत्रि ३६० निघ्ना
 हीना विधेर्दिनगते खगभुक्तियाताः ।
 स्युस्ते नवाद्रिकुगुणाष्टगजेषुपञ्च-
 नन्देन्दवः १९५५८८३१७९ शकमुखे सशका अभीष्टाः ॥ ५ ॥

सौरवर्षमुखसिद्धखेचरा ।
 एकवर्षगतिभिर्विशोधिताः ।
 उच्चपातसहिताः क्रियादिगा
 यद्गुणाभिरिह ते गताब्दकाः ॥ ६ ॥

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p. 46_a R₁, f. 2r V₄

f. 2r B₄

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Verse 4 numbering corrected from 3 to 4 V₂ 1 याताः] याता V₅ महदिने] मह [x]दिने
 V₂ ६] om. B₅IM₃R₁V₂V₃V₄V₅ षड् M₂ 2 न्स्युः] न्स्यः V₄ २७] om. IM₃R₁V₂V₃V₄V₅
 युगानि] यु x x B₅ ३] om. B₄B₅IM₁M₂M₃R₁V₂V₄V₅ 3 नन्दाद्रि] नन्दाद्रि B₅ दहनाः] दहना V₃
 ३१७९] om. B₅M₃R₁V₃ वत्सराश्च] वत्सराश्चे (त्) marg,s R₃ व (त्) a सराश्च V₅ 4 सच्छालि] सच्छाल [r]
 B₅ शक] के श B₅ corrected from शके to शक V₅ प्रभवे] प्रभवेः I प्रभवे V₄ प्रयाताः] प्रयताः M₁
Verse 5 before verse begins [स्युस्ते नवाद्रि] V₃ 5 ४७४००] om. B₄B₅IM₃R₃V₂V₃V₄
 ४७४०० शरदः R₁ रसत्रि] रसस्त्रि V₄ ३६०] om. V₃V₅ निघ्ना] निघ्नाः B₅V₅ 6 हीना] हीनं
 B₅, हीना M₃, [x](ही) marg,s ना V₅ याताः] यातः V₄ 7 स्युस्ते] स्युःस्ते B₅ कुगुणा] कुगुणा
 M₃ गजेषु] गुणेषु M₁M₂ 8 नन्देन्दवः] नन्देद[x]वः B₅, दे नै दवः M₂, नन्देदवः R₁, नन्देदव V₅
 १९५५८८३१७९] om. R₁ शकमुखे] कमुखे B₅, दशकमुखे M₂ सशका] x शका B₅, संशका M₁M₂
Verse 6 not numbered V₃ 9 चरा] चराः R₁ 10 गतिभिः] गति V₄ विशोधिताः]
 वियोजिताः B₅V₃V₅, विवर्जिताः M₁M₂, विशोधिता M₃ after विशोधिताः pādas ab repeated but
 crossed out I 11 सहिताः] सहिता B₅M₃ सहि [x]ताः I, सताः V₄ क्रियादिगा] क्रियादिका V₃
 12 यद्गुणा] (य) marg,द्गुणा I रिह] रह B₅, रीह M₃ गताब्दकाः] गता [x](ब्द) marg,काः B₅, गणाब्दकाः
 M₃

विधेर्दिनादौ युगपत्समस्तं

भूत्वा ग्रहाः प्राग्गमनप्रवृत्ताः। ।

f. 2r V₃

इतीरितं वेदविरोधिनस्ते

f. 2r I

ब्रह्मार्कचन्द्रादिमताद्विभिन्नम् ॥ ७ ॥ (a)

f. 1v R₃

ब्रह्मा प्राह च नारदाय हिमगुर्यच्छौनकायामलं

5

माण्डव्याय वसिष्ठसञ्ज्ञकमुनिः सूर्यो मयायाह यत्। ।

f. 2r B₅

प्रत्यक्षागमयुक्तिशालि तदिदं शास्त्रं विहायान्यथा

यत्कुर्वन्ति नरा न निर्वहति तद्विज्ञानशून्याश्चिरम् ॥ ८ ॥ (b)

मुनिप्रणीते मनुजैः

क्वचिच्चेदृश्यते ऽन्तरम् ।

10

तदा तदेव संसाध्यं

न कार्यं सर्वमन्यथा ॥ ९ ॥ (c)

Verse 7 1 दिनादौ] दिना[x]दौ R₁ युग] युग V₂ 2 भूत्वा] भूत M₃ ग्रहाः] ग्रह M₁M₂
प्राग्गमन] प्राणमन B₅M₁M₂ प्राग्गमनः R₁ प्राग्गमने V₅ 3 इतीरितं] इतीरि[x]तं V₂ इतीरितं V₃ वेद] वद
B₅ 4 मताद्वि] मतान्न M₃ मतद्वि R₁ **Verse 8** 5 प्राह] माह M₃ च्छौनकायामलं] च्छौनकायाखिलं
IV₂, च्छौनकामलं M₂, च्छौनकायामल M₃ 6 वसिष्ठ] वशिष्ठ R₁V₅, वसिछ^{supl} R₃, वसिष्ट[] V₄
मयायाह] मपायाह R₁ यत्] य x B₅ रत् M₃ 7 प्रत्यक्षागमयुक्तिशालि] प्रत्यक्षागमत्सुखिशालि R₁,
प्रत्यक्षागमयुक्तिशालि [x] V₃ तदिदं] तमिदं B₄B₅ विहायान्यथा] विहान्यथा B₄, विहा (या)^{supl}न्यथा B₅
8 नरा] निरा V₄ निर्वहति] निर्वहति M₁ तद्विज्ञान] तद्वि[x x](न)^{marg} B₅ शून्याश्चिरम्] शून्यस्थिरं
M₁, शून्यश्चिरं R₃ **Verse 9** numbered 10 V₃ 9 मुनि] मुनिः M₁M₂ मनुजैः] मनुजै
M₁R₁ 10 ते ऽन्तरम्] ते नरः R₁, तैत[x](रं)^{marg,s} V₅ 11 संसाध्यं] ससाध्य R₁, ससाध्य V₄
12 कार्यं] कार्य[] B₅

(a). This verse is quoted in Muniśvara's *Siddhāntasārvabhauma* without any variants (citation given in the commentary). (b). This verse is quoted in both Muniśvara's *Siddhāntasārvabhauma* and Kamalākara's *Siddhāntatattvaviveka*. In the former the verse is as given above (although a variant reading giving भृशम् for चिरम् in *pāda* d is noted by the editor), but in the latter, in which no attribution is found, we find वशिष्ठ for वसिष्ठ in *pāda* b, and *pāda* d reads यत्कुर्वन्ति नराधमास्तु तदसद्वेदोक्तिशून्या भृशम्. See the commentary for more information and citations. (c). This verse is quoted in Muniśvara's *Siddhāntasārvabhauma* without any variants (see commentary for citations).

यथा वेदोक्तमन्त्रेषु
न वीर्यं दृश्यते क्वचित् ।
तत्पुरश्चरणं कुर्या -
न्न कार्यं सर्वमन्यथा ॥ १० ॥

f. 33r V₂

तदङ्गीकृतमस्माभि -
र्विज्ञानं मुनिसम्मतम् ।
दृक्समं वासनावेद्य -
मनुभूय मुहुः पुरा ॥ ११ ॥

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p. 46_b R₁

f. 2v V₄

रससुरत्रिनभश्चरबाणभू १५९३३३६ -
परिमिता हि युगे ऽधिकमासकाः ।
यमशराकृतिकुञ्जरखेषुदृ २५०८२२५२ -
क्समयुगावमसञ्चय ईरितः ॥ १२ ॥

10

Verse 10 not numbered V₃ 2 दृश्यते] दृश्य [तेतरं] ते V₂ 3-4 कुर्यान्न] कुर्यान् B₄B₅, कार्यं न IM₃ कृत्वा न glossed as कुर्यान्न in margin by a V₅ **Verse 11** 5 कृतमस्माभि] कृतमस्माभि M₂ 6 विज्ञानं] वि(ज्ञा)_{marg}नं B₄, विज्ञानि IM₃V₂, विज्ञा [f]नं R₃ सम्मतम्] समतं B₄, सत्तमं B₅ 7 दृक्समं] दृक्समा V₄ 7-8 वेद्यम] वेद्य (ऽ)_{supl,s}म B₄, वेद्यम B₅ **Verse 12** 9 त्रि] क्रि V₄ नभश्चर] भनश्चर M₃ १५९३३३६] placed after ऽधिकमासकाः in *pāda* b IV₂ placed after परिमिता in *pāda* b M₁M₂ om. M₃V₃ १५९ (३)_{supl,s} ३३६ V₅ 10 हि] [x](हि)_{marg,s} V₅ मासकाः] मासाः M₂ 11 २५०८२२५२] placed after ईरितः in *pāda* d IM₁M₂V₂, om. M₃V₃ placed between सम and युगा V₄

तरणिचन्द्रमसोर्भगणान्तरं

भवति तद्विधुमाससमुच्चयः ।

f. 2v B₄

रससुरामरसिन्धुगुणेषुभिः ५३४३३३३६

परिमितः स युगे मुनिसम्मतः ॥ १३ ॥

लक्षाहताः। पक्षशराक्षपञ्च -

5 f. 2v I

चन्द्रा १५५५२००००० युगे स्युर्दिवसाः खरांशोः ।

चान्द्रो दिनौघः खगजाभ्रपूर्ण -

f. 2v B₅

पूर्णाभ्ररामाभ्रनृप १६०३०००००० प्रमाणः। ॥ १४ ॥

f. 33v V₂

अष्टद्वष्टात्यष्टिखेटाद्रिकुध्र -

बाणक्षोण्यः १५७७९१७८२८ स्युर्युगे भूदिनानि ।

10

तारावारा दन्तिदस्रोर्गगाद्रि -

रामद्विद्विदीपिपञ्चेन्दु १५८२२३७८२८ सङ्ख्याः ॥ १५ ॥

f. 2v V₃, f. 2r M₂,
f. 2r R₃ & f. 13r V₅

Verse 13 not numbered M₃ 1 मसो] समो V₄ भंगणान्तरं] नंगणान्तरं M₁ 2 तद्विधु] तद्विधु B₅ यो विधु V₅ माससमुच्चयः] मास [x]स(मु) marg चयः V₃ मास [r]समुच्चयः V₄ 3 गुणेषुभिः] गुणेषु (भिः) marg B₄ गुणेषुभिः B₅ गुणेषुभिः M₃ ५३४३३३३६] placed after समुच्चयः in *pāda* b M₁M₂, om. M₃R₁V₃, placed between गुणेषु and भिः in *pāda* c R₃, ५३४३३३३६ V₄ 4 परिमितः] परिमितं M₁M₂ सम्मतः] समतं M₁M₂ **Verse 14** not numbered V₂ 5 हताः] हता (:)supl V₅ पक्ष] पक्ष M₁ शराक्ष] शराभ्र I पञ्च] पंक्षा]च M₂, om. R₁ 6 १५५५२०००००] placed after युगे in *pāda* b B₄B₅M₁M₂R₃, placed after खरांशोः in *pāda* b I, om. M₃R₁V₃, placed after दिवसाः in *pāda* b V₂, १५५५२००००० corrected to १५५५२००००० V₄ दिवसाः] दिवसा B₄B₅R₃ 7 दिनौघः] दिनौघः M₁M₂ गजाभ्रपूर्ण] गजा अपूर्ण M₃ 8 नृप] नृष R₁ १६०३००००००] placed between नृ and प in *pāda* d B₄B₅R₃, placed after verse number I १६०३०००००० after verse number M₁M₂, om. M₃V₃, placed after प्रमाणः in *pāda* d V₂V₅ प्रमाणः] प्रमाणा M₁M₂, प्रमाणाः M₃V₄, प्रमाण [r]: V₂V₅ ॥ १४ ॥ **Verse 15** misnumbered 14 V₅ 9-10 कुभ्रगाण] कुभ्रगाण B₄B₅R₃, कुभ्रगाण R₁, शैलगाण V₅ 10 १५७७९१७८२८] placed after युगे in *pāda* b B₄B₅R₃, placed after भूदिनानि in *pāda* b IV₂V₅, १५७७९१७८२८ M₁, om. M₃V₃ युगे] युगा M₁M₂R₃ 11 तारा] [x]तारा I दन्ति] दत I 12 राम] रामा M₃, राम V₂ द्विद्वि] द्विद्वि R₁ द्वीपि] द्वीप I १५८२२३७८२८] placed after सङ्ख्याः in *pāda* d B₄B₅IM₁M₂R₃V₂V₄, om. M₃V₃, १५८२२३७८२८ placed after सङ्ख्याः in *pāda* d R₁, १५८२२३७८[३]२८ placed after सङ्ख्याः in *pāda* d V₅ सङ्ख्याः] संख्या (:)supl V₅ ॥ १५ ॥ **Verse 16** misnumbered 15 V₅

अवनिवासरचान्द्रदिनान्तरे
 ऽवमदिनानि वदन्ति विदः सदा ।
 रविनिशाकरवासरसञ्चया -
 न्तरसमाधि|कमा|सकवासराः ॥ १६ ॥

f. 3r V₄, p. 47 R₁

भगणवर्जितभभ्रमसम्मिति -
 भवति खेचरभूदिनसञ्चयः ।
 इह सुरूढतया न हि वासना
 निगदिता सुधिया स्वधियैव सा ॥ १७ ॥

5

सूर्यसौम्यसितपर्यया युगे
 पूर्णपूर्णखखदन्तसागराः| ४३२०००० ।
 षट्सुरत्रिशरगिर्य|गेषवः ५७७५३३३६
 शीतरश्मिभगणा बुधैः स्मृताः ॥ १८ ॥

10 f. 12r M₃

f. 3_ar B₅

f. 34r V₂

Verse 16 1 चान्द्र] चंद्र M₁M₂V₃V₄ 2 ऽवमदिनानि] विधुदिनानि V₄ 4 मासकवासराः]
 माससराकराः M₂, मासकवासरः M₃ **Verse 17** 5 भगणवर्जित] भगणवाज्जित R₁ भगण[x]व[x]र्जित
 V₂ भभ्रम] मभ्रम M₁M₂ 6 भवति] भवनि M₃ खेचरभूदिन] खेचर(भू)marg न M₁, खेचरभूदिन M₃,
 (खेचर)marg भू दि न [x] V₃ 7 सुरूढतया न हि] सुरूढतया हि M₃, सुरूढतया न हि V₃V₄ वासना]
 वासरना R₁ 8 सुधिया] सु[x]धिया M₃ स्वधियैव सा] स्वधियोच्यते I, सुधियैव सां M₁, सुधियैव सा M₂,
 three last syllables यैव सा marked and glossed in margin as योच्यते by s V₅ **Verse 18**
 not numbered V₃ numbered 19 V₄ 9 सूर्य] सूर्य V₄ युगे] [वि?धे?] युगे V₃
 10 ४३२००००] om. M₃V₃ 11 ५७७५३३३६] ५७७५३३६ M₂, om. M₃V₃ second to last digit corrected
 from ६ to ३ V₂ 12 शीतरश्मि] शीतरश्मि V₄

दन्तदन्तिरसरन्ध्रदृग्यमा २२९६८३२
मङ्गलस्य युगमण्डलोन्मितिः। ।
खाङ्गखागगुणगोऽद्रिभू १७९३७०६० मयो
रौहिणेयचलतुङ्गपर्ययाः ॥ १९ ॥

f. 3r B₄

पूर्णलोचनयमाब्धिषड्गुणा ३६४२२०
गीष्पतेर्भगणसम्मितिर्मता
ऋत्वगत्रियमदृक्खपर्वता ७०२२३७६
भार्गवाशुभगणा युगे मताः ॥ २० ॥

5 f. 2r M₁

Verse 19 not numbered V₃ 1 दन्तदन्ति] दन्तिदन्त R₁ रस] corrected from रसं to रस V₄
२२९६८३२] om. M₃V₃, रन्ध्रदृग्यमा R₁, २२९६९३२ V₄, २२९६८३ [x]२ V₅ 2 मण्डलोन्मितिः] मंडलोन्मितोः
M₁, मंडलोन्मिताः M₂, मंड [r]लोन्मितिः V₂ 3 खाङ्गखाग] खांगखांग B₄B₅M₂, खांग M₃, खां [कं]गखाग V₂
१७९३७०६०] placed after मयो in *pāda* c B₄B₅IM₁M₂R₃V₄, om. M₃V₃, खांगगुणगो R₁, placed after
पर्ययाः in *pāda* d V₂, १७९३ [x]७०६० placed after मयो in *pāda* c V₅ 4 रौहिणेयचल] रोहिणेयवल
M₁M₂, रौहिणेयचल V₄, रौहिणेयच [x](ल)_{marg,s} V₅ पर्ययाः] corrected from पर्ययाः to पर्ययाः M₁,
पर्यया R₁ **Verse 20** not numbered V₄ 5 लोचनयमाब्धि] लोचनयमा [x](ब्धि)_{marg,s} B₄,
लोचनयमाब्धि R₃, लोचदृगब्धि V₂, लोचनदृगब्धि V₄ ३६४२२०] om. M₃V₃ ३६४३२० V₄ 6 गीष्पते]
गीष्पते M₂, गीष्पति M₃, गीष्पते R₁ भगण] भं [x]गण I, भगण V₄ मता] मंता २० (additional,
wrongly placed verse number) V₃ 7 ऋत्व] [x](ऋ)_{marg,s} त्व B₄, न्स्त्व R₃, x त्व first syllable
glossed as ऋ in margin by a V₅ दृक्ख] दृख M₁ पर्वता] पर्वताः R₁ ७०२२३७६] om.
M₃V₃, see *pāda* d R₁, ७०२२३७ (६)_{supl} V₅ 8 भार्गवाशुभगणा] भार्गवोच्चभगणा I, भार्गवाशुकगणा M₂,
भार्गवाशुभगणाः R₁, भार्गवाशुभ [r]गणा V₄, the last syllable written सु but marked by scribe V₅
युगे मताः] युगे मता (ः)_{supl} B₄, युगमेताः M₂, युगे मता R₃V₅

मतङ्गाङ्गपञ्चाङ्गवेदेन्दु १४६५६८ सङ्घा
 पतङ्गप्रसूतस्य चक्रप्रमाणम् ।
 त्रिखाश्वीभनागाब्धय ४८८२०३ श्वक्रमानं
 विधोर्मन्दतुङ्गस्य पूर्वद्युभुक्त्या ॥ २१ ॥

f. 3v V₄

भुजङ्गाग्निदृग्दन्तदस्त्रा २३२२३८ विलोमाः
 स्मृताः पर्ययाः । सैहिकेयेन्दुपाते ।
 सहस्रा । १००० हताः कल्पजाता भवेयु-
 स्त एवाथ सूर्योच्चचक्राणि कल्पे ॥ २२ ॥

5

f. 3av B₅

p. 48 R₁

शैलमङ्गलगुणाः ३८७ । कुजादथो
 वेदशून्य । यमला २०४ मृदूच्चजाः ।
 नागषड्गुण ३६८ मिताः खखग्रहाः ९०० ।
 पञ्चपावकशरा ५३५ नवाग्नयः ३९ ॥ २३ ॥

f. 34v V₂

10 f. 3r V₃

f. 2v R₃

Verse 21 numbered 20 R₁ 1 मतङ्गाङ्ग] मतङ्गाङ्ग M₃, म[र]तङ्गाङ्ग V₄, मत[र]गाङ्ग V₅ पञ्चाङ्ग]
 पञ्चाङ्ग V₄ १४६५६८] placed after सङ्घा in *pāda* a IM₁M₂V₄V₅, om. M₃R₁V₂V₃ 2 पतङ्गप्रसूतस्य
 य] पतङ्गाङ्गसूतस्य I, पतङ्गसूतस्य R₁, पतङ्ग[स्य]प्रसूतस्य V₂ 3 त्रिखाश्वी] त्रिखा[र]श्वी M₂, त्रिखा[f]श्वी M₃
 भनागाब्धय] नाग(र)^{supl}ब्धय B₄, नागाब्धय R₁, नागब्धय R₃, [x x](भना)^{marg,s}गाब्धय V₅ ४८८२०३]
 ४८८२० placed between गाब्ध and य in *pāda* c M₂, om. M₃V₃, see *pāda* d R₁, placed after
 मानं in *pāda* c V₄, (४८८२०३)^{marg,s} V₅ श्वक्र] श्व M₃ 4 विधो] विधो M₂ मन्दतुङ्गस्य]
 म[^{४८८२०३}x](द)^{marg,s}तुङ्गस्य B₄, मंद[उ]तुङ्गस्य B₅, मंगतुङ्गस्य M₃, मंदतुङ्गस्य R₁, मर्ममृतुङ्गस्य R₃ पूर्व] पूर्वं M₃
Verse 22 numbered 21 R₁ 5 भुजङ्गाग्नि] भुजङ्गामि B₅, भुजङ्गाग्नि marked and in margin
 २३२२३८ R₁ दृग्दन्तदस्त्रा] दृदन्तदस्त्रा M₂, दृग्दन्तदस्त्रा V₄ २३२२३८] placed after पाते in *pāda* b IV₂,
 om. M₃V₃, see *pāda* a R₁, placed after विलोमाः in *pāda* a V₅ विलोमाः] विलोमा M₂V₅, विलोमः
 V₃ 6 स्मृताः] स्मृ[f]िताः V₅ पर्ययाः] पर्यायाः V₄ सैहिकेयेन्दु] सैहिकेयेन्दु M₂, सौहिकेयेन्दु M₃, सिंहिकेयेन्दु
 R₁, सिं[f]हेकेयेन्दु V₃ पाते] पीते M₁ 7 १०००] om. IM₃R₁V₂V₃V₅, placed after हताः M₁M₂
 हताः] हता B₄B₅M₁V₃ कल्प] कल्प V₄ भवेयु] भवेत्यु M₃ 8 स्त] स्ता V₄ एवाथ] एवाथ R₃
 सूर्योच्च] सूर्योच्च M₃ चक्राणि] क्राणि V₄ **Verse 23** numbered 231 V₄ 9 ३८७] om.
 M₃V₃ मङ्गलगुणाः R₁ ३८७] कुजादथो] कुजादथो B₅, कुजादथा M₁M₂, कुजादितो R₁, कुजादथो V₄, कुजादथो V₅
 १० शून्य] शून्य R₁ २०४] यमला] मला M₃ २०४] om. M₃V₃ see *pāda* b R₁ placed after जाः in *pāda*
 b V₂ मृदू] मृदू B₄B₅, मृ[ड](दृ)^{marg,s} V₅ जाः] जा R₁ 11 नागषड्गुण] ना[ख](गष)^{marg}गुण
 V₃, नागषट्[x]गुण V₅ ३६८] placed after मिताः in *pāda* c B₄B₅IM₁M₂R₁R₃V₂V₄, om. M₃V₃,
 corrected from ३ x ८ to ३६८ V₅ मिताः] मिता IR₁ खख] ख V₄ ग्रहाः] ग्रहा B₄B₅R₃
 ९००] om. M₃V₃ 12 पावक] भावक M₂, पावक[ग्रहा] M₃, प(र)^{supl}वक V₅ ५३५] om. M₃V₃,
 (५३५)^{marg,s} V₅ ३९] om. M₃V₃V₄, [५३५] ३९ V₅ ॥ २३ ॥] २३१ V₄, स्तो २३ V₅

कल्पे पातानां कुजाद्व्यस्तगानां
 पारावारैकद्वि २१४ सङ्ख्याः क्रमेण ।
 अष्टेभाम्नाया ४८८ युगाद्रीन्दवो १७४ ऽथ
 रामाभ्राङ्काः ९०३ पक्षषङ्काङ्ग ६६२ तुल्याः ॥ २४ ॥

ब्रह्मार्कशीतगुवसिष्ठपुलस्त्यमुख्यै -
 स्तन्त्रेषु ये समुदिता भगणास्त एते ।
 अत्रोपपत्तिममलां सुगमामपूर्वा
 वक्ष्ये ऽधुना भगणसाधनबोधकर्त्रीम् ॥ २५ ॥

अम्भःसमीकृतमहीतलसंस्थितस्य
 च्छाया दिनार्धघटिकासु समस्य ^(a) शङ्कोः ।
 याम्योत्तरा भवति सैव तदुत्थमतस्य -
 पुच्छास्यतस्त्वपरपूर्वदिशौ भवेताम् ॥ २६ ॥ ^(b)

Verse 24 1 कल्पे] कस्ये V₄ 2 वारैक] वारैक M₂ २१४] placed after सङ्ख्याः in *pāda* b M₁M₂V₂, om. M₃R₁V₃ सङ्ख्याः] संख्या M₁M₂M₃, संख्याः R₁, संख्या (:) ^{supl} V₅ 3 अष्टे] corrected from अष्टौ to अष्टे V₅ भाम्नाया] भाम्नाया B₅, भाम्नाया M₃, भाम्नाया R₁, भाम्नाया V₄ ४८८] om. M₃V₃, see *pāda* c R₁ युगा] युगा R₁, corrected from युगां to युगा V₄ १७४] placed after ऽथ in *pāda* c IV₂, om. M₃V₃ ऽथ] थ [r] V₅ 4 भ्राङ्काः ९०३] भ्राङ्काः ६०३ B₄B₅R₃, भ्राङ्का ९०३ M₁R₁, भ्राङ्काः M₃, भ्राङ्काः V₃ षङ्काङ्ग] षङ्काङ्ग [क] M₂ ६६२] placed after तुल्याः in *pāda* d B₄B₅M₁M₂R₃, om. M₃V₃ **Verse 25** 5 ब्रह्मार्क] marked and glossed as अत्रोपपत्तिः by s B₄B₅, ब्रह्मार्क M₂ शीतगु] शीरुगु R₃ वसिष्ठ] वसि [x] (ष्ट) ^{marg,s} B₄, वशिष्ठ R₁V₅, वसिष्ठ R₃ पुलस्त्य] पुल [x] (स्त्य) ^{marg,s} V₅ 6 समुदिता भगणा] निगदिता भागणा V₄ 7 अत्रोपपत्तिममलां] अत्रोपपत्तिविमलां R₁ सुगमाम] सगमा (ऽ) ^{marg,s} B₄ पूर्वा] पूर्व R₃ 8 वक्ष्ये] व [x] क्ष्ये B₄ ऽधुना] धु [नु] ना M₂ भगण] भग [x] ण R₁ कर्त्रीम्] कर्त्री M₁, कर्त्री M₂M₃, कर्त्रीम् V₄V₅ **Verse 26** 9 तल] त (ल) ^{supl} V₃ संस्थितस्य] संस्थित M₂ 10 दिनार्ध] corrected from दिनार्ध to दिनार्ध M₃ समस्य] सममध्य M₁, समध्य M₂, शमस्य V₅ शङ्कोः] शकाः B₄, शको (:) ^{supl} R₁ 11 तदुत्थ] तदुच्च M₁, तदुत्था V₄ 12 दिशौ] दिशो M₂M₃ भवेताम्] भवेता R₃

(a). The reading दिनार्धघटिका सुसमस्य is also possible. (b). This verse is identical to verse 2.3.2.

स्तम्भस्य शोभनतरुप्रभवस्य मूल-
 धारा यथा यमकु|बेरदिगायता स्यात् ।
 लम्बोपमस्य सुसमस्य तु पूर्वभागे
 कीलं निवेश्य नलिकां शिथिलां च कीले ॥ २७ ॥

f. 35r V₂

याम्योत्तरामथ तथा प्रविलोक्य सूर्य
 तुर्यादियन्त्रत इहोन्नतभागमानम् ।
 ज्ञात्वा विशोध्य नवते १० नतभागकाः स्यु-
 स्तत्स्वाक्षकान्तरयुती समभिन्नदिक्के । २८ ॥

5

क्रान्त्यंशास्तज्ज्या जिन २४ ज्याविभक्ता
 त्रिज्यानिघ्नी तद्धनुर्दोर्लवाः स्युः ।
 तिग्मांशोस्तद्वासरे रात्रिवक्त्रे
 दृष्ट्वा धिष्यं| कल्पयेत्तत्पदं हि ॥ २९ ॥

10

f. 3v V₃

Verse 27 number omitted with *pādas* cd V₅ 1 तरु] तरुः M₁M₂, तत् V₄ मूल] मूलं corrected to मूल V₃ 3-4 लम्बो—कीले om. but added in margin by s: लम्बोपमस्य सुसमस्य तु पूर्व[कीलं]भागे कीलं निवेश्य नलिकां शिथिलां च कीले ॥ २७ ॥ V₅ 3 पूर्व] पूर्व M₁, पूर्व M₂ 4 नलिकां शिथिलां] शिथिलां नलिकां B₄R₃, नलिका शिथिलां R₁ कीले] कीलैः B₅ **Verse 28** not numbered V₄ 5 याम्योत्तरा] याम्योत्तरा (रा) ^{supl} B₅ प्रविलोक्य] प्रविलोक्य M₂ सूर्य] सूर्य M₁M₂, corrected from सूर्य to सूर्य V₄ 6 तुर्यादि] तुर्य्य (r) दि B₄, तुर्यां [f] दि B₅ यन्त्रत] यत्त V₄ इहोन्नत] इहोन्नत M₁ 6-7 भाग—नत om. V₄ 7 १०] om. B₅IM₃R₁V₂V₃V₅ भागकाः] भागकाः M₃ 8 कान्तर] कां [क]तर V₂ दिक्के] । **Verse 29** before the verse is a header and a partial *vasantatilakā* verse marked by s as not being in his other manuscript: रात्रौ दिक्साधनं ऊर्ध्वाधरा भ्रवज्ञाननपुच्छतारा संलक्षयेन्नलिकयाग्रनिबद्धलवं याम्योत्तरा भवति सैव ० २४ (for the last incomplete *pāda* see verse 26) V₅ 9 क्रान्त्यंशास्तज्ज्या] क्रान्त्यांशास्तज्ज्या I, क्रान्तिज्यास्तज्ज्या R₁, क्रान्त्यं [श्या]शास्तज्ज्या V₃, क्रान्त्यंशास्तज्ज्या V₄, क्रान्त्यंशास्त [r]ज्ज (ज)या V₅ २४] om. B₄B₅IM₃R₁R₃V₂V₃V₄V₅ 10 निघ्नी] निघ्ना R₁ तद्धनु] तद्धनु M₃ दोर्लवाः] दोर्लवा I, दोर्लवा M₁M₂, दोर्लवा M₃, दोर्लवा R₁, दोर्लवाः V₃ 11 द्वासरे] द्वासरे [ण] V₃ 12 कल्पये] कल्पये R₃

एवं सूर्यं सायनं प्राग्वदित्वा
 स्पष्टं भूयो वासरे ऽन्यत्र भुक्तिः ।
 स्पष्टा भान्वोरन्तरे तल्लघुत्वे
 यावान्सूर्यस्तत्समं तस्य तुङ्गम् ॥ ३० ॥

f. 2v M₂

मध्या भुक्तिः स्यादलं स्पष्टतस्त -

5 f. 3r R₃ & f. 35r

V₂

ङुक्त्यल्पत्वानल्पसङ्ख्यायुतेर्यत् ।
 पृथ्वी भुक्तिः स्यात्तदा स्पष्टतुल्यो
 मध्यार्कस्तं राशिपूर्वं विदित्वा ॥ ३१ ॥

f. 4r B₄

ततः प्रतिदिनं मध्य -

f. 4v V₄

गत्या मध्यं प्रचालयेत् ।

10

कालान्तरेण तन्मध्य -

स्फुटयोरन्तरं फलम् ॥ ३२ ॥

Verse 30 1 सायनं] (सायनं)_{marg} V₃ प्राग्वदित्वा] प्राग्व [तिग्मांशोस्तद्वासरेर]दित्वा R₃ 2 स्पष्टं]
 स्पष्ट V₄ 3 भान्वो] attempted correction from भावो to भान्वो and with न्वो in margin by s
 B₄, भावो R₃ तल्लघुत्वे] marked and glossed as स्पष्टगतिलघुत्वे by s B₄, लघुत्वे V₄ 4 यावान्सूर्यं]
 यावत्सूर्य M₂, यावात्सूर्य M₃, याव(र)सूर्य V₅ तस्य] om. V₄ तुङ्गम्] तुङ्ग[र] B₄ **Verse 31**
 5 भुक्तिः] भुक्ति M₃R₁ 5-6 स्पष्टतस्तद्] स्पष्टतत्तद् B₄M₁M₂, स्पष्टतद् I, स्पष्टतत्तद्भु M₃, स्पष्टमेति
 भु R₁, स्पष्टमेत्तद् R₃, स्पष्टमेतद् V₂V₄, स्पष्ट[x]त(त्त)_{marg,s}भु V₅ 6 ऋत्त्यल्पत्वानल्प] ऋत्त्यत्वानल्प R₁,
 ऋत्त्यल्पत्वात्तस्य with the two last *akṣaras* marked and variant reading नल्प recorded in margin V₂,
 ऋत्त्य(ल्प)_{marg}त्वानल्प V₃, त्स्यल्पत्वात्तस्य V₄ युतेर्यत्] युतेश्च V₅ 7 पृथ्वी] marked and glossed as
 परमाधिकगतिः in margin by s B₄, स्पष्टा I, marked and variant reading स्पष्टा recorded in margin
 by s V₅ भुक्तिः] भुक्तिः[x] V₃ 8 मध्यार्कस्तं] मध्यो कस्तं B₄R₃, मध्यार्कस्तं M₂, मध्यार्कं तं R₁ पूर्व]
 पूर्व R₁ **Verse 32** 9 प्रतिदिनं] प्रतिदिन R₁, प्रदिनं (last *akṣara* corrected from नं to नं) V₄
 10 प्रचालयेत्] प्रचाल्ययत् B₅, प्रचाल्ययत् IR₁V₃V₅

साम्यं यत्र भवेन्मध्य-

स्फुटगत्योः परं फलम् ।

f. 4r I

ज्ञेयं तज्ज्यासमं व्यास-

p. 50 R₁

दलं नीचोच्चमण्डले ॥ ३३ ॥

एवं यावान्भवति सविता राशिभागादिरूप-

5

स्तावान्यैः स्यात्सविकलदिनैस्ते भोगाभिधाः स्युः ।

एभिस्त्वेको भवति भगणश्चेत्तदा भूदिनैः किं

f. 3b v B₅

कल्पे साध्या इति बुधजनैः पर्ययास्ते ऽनुपातात् ॥ ३४ ॥

याम्योदग्वलयागतं शशधरं तुर्येण पूर्वोक्तव-

द्विद्धा सायकसंस्कृतापम इति ज्ञेयो ऽथ तत्कालजाः ।

10 f. 36r V₂

याता रात्रिघटीः स्फुटीकृतघटी यन्त्रेण बुद्ध्या रवेः

कार्यं मध्यविलग्नमग्रविधिना लङ्कोदयैः प्रस्फुटम् ॥ ३५ ॥

Verse 33 1 साम्यं] याम्य R₁ 2 स्फुट] स्फुट [x] V₃ गत्योः परं फलम्] गत्योः (परं)_{marg,s}
फलं B₄, गत्या परं फलम् I, गत्योतरं फलं R₁, गत्योः फलं परं V₂, गत्योः [x] परं फलं V₅ 3 समं]
समं [r] B₅, सम M₂ 4 दलं] दलं [r] V₅ नीचोच्चमण्डले] नीचोच्चमण्डले R₁ **Verse 34**
5 यावान्भवति सविता] यावान्सविता B₅, यावान्भवति सहिता M₁, यावान्भवति सविता R₁, यावात्भवति सविता V₅
6 स्तावा] स्ताव V₄ न्यैः] न्येः I, न्यै R₁ स्यात्सविकल] स्या सविकल V₃ स्ते] स्ते R₁, corrected
from स्ते to स्ते V₅ भोगाभिधाः स्युः] भोगाभिधा स्युः IM₁M₃, भोगाविधा स्युः M₂, भोगाभिधा स्यु R₁,
भोगाभिधाः स्युः । ३४ V₃ 7 एभिस्त्वेको] एभिश्चैको IV₂V₄ भगण] भगणा M₂ दिनैः किं] दिनौ
कि R₁, दिनैः (ः f) कं V₅ 8 साध्या] साध्या [x] V₃ जनैः] जनैः [x] B₄ स्ते] स्ते [r] M₁
Verse 35 9 याम्योद] याम्याद M₁, याम्योद् M₃, याम्योद R₁ पूर्वोक्तव] पूर्वोक्तव R₁, पूर्वोक्त V₄
10 द्विद्धा] द्विद्धा M₂ संस्कृतापम] संस्कृतो पम B₅M₁M₂ ऽथ] य R₁, य R₃ तत्काल] the
akṣara ल is corrected from something else and ल is given again in the margin V₃ जाः]
जा B₄, जः V₄ 11 याता रात्रि] याता रात्रि M₂, याता रात्रि R₁, या [x] ता (रा)_{marg} त्रि V₃, यात्रा सत्रि
V₄ घटीः] घटी M₁M₂M₃R₁, घटिः V₃, घटी (ः)_{supl} V₅ स्फुटी] [x] (स्फुटी)_{marg} I, स्फुटो R₁
कृत] कृ [f] त B₄, कृति R₃ यन्त्रेण] यंत्रण M₁ 12 कार्यं] कोपं M₃, corrected from कोर्यं to कार्यं V₄
मग्र] मग्र B₅M₁M₂R₃, om. V₄, म (ग्र)_{marg,s} V₅ लङ्कोदयैः] लंसोदयैः R₁, लंकोकोदयैः V₃

तत्समो हिमगुरायनदृष्टि -
 कर्मसंस्कृत इतीरितमाद्यैः
 प्रस्फुटापमखमध्यलग्नका -
 पक्रमान्तरमिषुर्हिमगोः स्यात् ॥ ३६ ॥

दक्षिणबाणाभावे
 यश्चन्द्रो भगणशोधितः पातः। ।
 पुनरप्येनं पातं
 ज्ञात्वा। कालान्तरे गतिः कार्या ॥ ३७ ॥

सूर्योच्चवद्विधूच्चं
 मान्दं ज्ञेयं गतिस्तथैवास्य ।
 अनया भगणाः साध्या
 महायुगे ब्राह्मकल्पे वा ॥ ३८ ॥

वक्रवक्त्रखचरैकपर्यये
 पूर्ववद्दिनगणं समानयेत् ।
 तन्महत्त्वलघुतैक्यखण्डकं
 तेन कल्पभगणांश्च साधयेत् ॥ ३९ ॥

Verse 36 1 तत्समो] तत्समो M₁ हिमगुरायन] हिमगुरा[हि]यन M₁ 2 इतीरित] इ[fi]तीरित M₃, इतीरित V₃ माद्यैः] माद्यैः B₅IM₃V₂V₄V₅ 3 पम] om. M₁ लग्नका] लग्न[र]का V₃
 4 पक्रम] पक् I, क्र R₁ मिषु] मि[हि]षु I हिमगोः] हिमगो M₁, हिमगो(:)subl I, हिमयोः R₁
Verse 37 5 बाणा] बाण M₁, राणा M₃ 6 यश्चन्द्रो] यश्चन्द्रो R₁, यश्चन्द्रो V₅ भगण] भगणा M₃,
 (भगण)marg V₂ पातः] corrected from पाते: to पातः I 7 रप्येनं] अथेनं R₃V₅ पातं] पात
 B₄, पानं V₅ 8 कालान्तरे] कालांतरेण IV₂V₄V₅, कालांतरे[क] V₃ गतिः] गति B₅R₁ कार्या] marked and glossed as साध्या in margin by s B₄, कार्या: B₅R₁, om. IV₂V₄V₅ **Verse 38**
 9 द्विधूच्चं] द्विधूच्च R₁ 10 मान्दं] माद्यं Ron वास्य] वा (ऽ)marg,sस्य with the last *akṣara*
 marked and glossed as विधूच्चस्य in the margin by s B₄, वा x [r] M₁, वास्या V₄, वास्य[r] V₅
 11 भगणाः] भगणा IV₃ साध्या] साध्या: R₁ 12 ब्राह्म] ब्राह्म[r] B₄, ब्रह्म M₁M₂R₁V₅ **Verse 39**
 13 वक्रवक्त्र] व[क]क्र वक्त्रे I, वक्रवक्त्र R₁, वक्त्रं वक्र V₅ खचरैक] खचरैरक M₂ 14 दिनगणं]
 दिनगतिं B₄, the *akṣara* ण is marked and the variant reading ति is added in the margin V₃
 15 न्महत्त्व] न्महत्त्व B₄B₅IM₁M₂M₃R₁V₂V₃V₄V₅ तैक्य] तै[x]क्य V₃ 16 तेन] [r]तेन V₅
 भगणांश्च] गतिकांश्च B₄R₃, corrected from भुगणांश्च to भगणांश्च I, भगणांश्च V₄

वेधसिद्धिखगमध्यमान्तरे
मन्दशीघ्रफलसंस्कृतिः सदा ।
व्यस्तशीघ्रफलसंस्कृता सती
केवलं भवति मन्दजं फलम् ॥ ४० ॥

निजाशुनीचोच्चसमे खगेन्द्रे
फलस्य नाशे ऽपि न मध्यतुल्यः ।
स्फुटग्रहः स्यादत एव मन्द-
मुच्चं ग्रहस्याप्यपरं च किञ्चित् ॥ ४१ ॥

स्वशीघ्रनीचोच्चसमेषु न स्या-
च्छीघ्रं फलं व्योमच।रेषु नूनम् ।
तदा स्फुटो यः स मृदुस्फुटो ऽथ
तन्मध्ययोरन्तरमत्र मान्दम् ॥ ४२ ॥

Verse 40 numbered 4 V_3 numbered 41 V_3 1 वेध] वेद्य R_1 मान्तरे] मांतरं
 R_1 2 मन्दशीघ्रफलसंस्कृतिः] मंदशी [x] ग्रफलसंस्कृतिः I, मंदफल [शीघ्र] संस्कृतिः M_3 , मंदशीघ्र [x] फलसंस्कृतिः
 V_2 , [x x] मंद (शीघ्रफलसं) marg, s स्कृतिः V_5 3 व्यस्त] व्यस्ता V_4 स्कृता सती] स्कृता [वपि] सती
 M_1 4 भवति] भविति M_2 मन्दजं फलम्] म (r) जं फलं B_4 , मंदजफलं M_3 , मंदनं फलं R_1 , मंद x x लं
 V_3 **Verse 41** 5 निजाशु] corrected from निजांशु to निजाशु V_2 , निजाशु V_3 , the *akṣara*
शु written as a सु with two half-circles on top of it (probably a correction is intended) V_5
5-6 नीचोच्च—फलस्य] marked and glossed as नीचोच्चसमे ग्रहे फलाभावः in margin by s B_4 5 नीचोच्च
नीचोच्च [x] I समे] समं R_3 , corrected from समं to समे V_5 खगेन्द्रे] खगेन्द्र M_1 , खगेन्द्रः R_3 , खकेद्रे V_3
6 फलस्य] फलस्या V_4 नाशे] नाशो V_2 , corrected from नाशो to नाशे V_5 न] तु R_1 मध्यतुल्यः]
 $\frac{3}{4}$ तुल्यः $\frac{2}{2}$ मध्य V_5 7 ग्रहः] ग्रह $M_1M_2M_3R_1V_3$ स्यादत] स्यदत R_1 स्या (द) marg, s त with the *akṣara*
स्या corrected from something else and the *akṣara* त probably originally a न V_5 मन्द]
मं (r) द B_5 , मांद V_2V_4 8 ग्रहस्याप्यपरं] ग्रहस्या x परं B_4 , ग्रहस्यास्त्यपरं $IM_3R_3V_2V_4V_5$, ग्रहस्यास्त्वपरं
 R_1 , ग्रस्याप्यपरं V_3 किञ्चित्] किञ्चित R_3 **Verse 42** not numbered V_3 9 शीघ्र] शीघ्र [r]
 B_4 , शिघ्र V_4 नीचोच्च] $\frac{3}{4}$ $\frac{1}{2}$ चो M_2 , नीचोच्च V_3 10 छीघ्र] छीघ्रं $B_5M_1M_2M_3V_2V_4V_5$, छीघ्र R_1
11 यः] य M_1 , यो R_1 स्फुटो] स्फु (टो) marg V_3 ऽथ] न R_1 12 तन्मध्ययो] [तन्मध्ययो] तन्मध्ययो
 V_3 मान्दम्] [f] मं (r) दं M_3 , मांदां V_4

सौरारमन्त्रिषु रवेः पुरतः स्थितेषु
मध्यग्रहात्स्फुटखगो ऽल्पक एव दृष्टः ।
पृष्ठस्थितेष्वधिक एव ततस्त्रयाणां
पूर्वैः श्वलोच्चमिनतुल्यमिति प्रदिष्टम् ॥ ४३ ॥

f. 4r B₅, f. 5v V₄

मान्दाभावे मन्दनीचोच्चतुल्यं
खेटं ज्ञात्वा तन्मितिः साधनीया ।
दैत्येज्यज्ञौ लग्नतुल्यौ कुजस्थौ
ज्ञेयौ। ताभ्यां तद्गती साधनीये ॥ ४४ ॥

5 f. 37r V₂

f. 5r I

यावत्कालं। सूर्यतो ऽग्रस्थितौ। स्त-
स्तावदृष्टौ पृष्ठसंस्थौ सदा तौ ।
तस्माज्ज्ञेयाः पर्ययाः सूर्यचक्रै-
स्तुल्याः कल्पे साधनार्थं ज्ञभृग्वोः ॥ ४५ ॥

p. 52 R₁, f. 5r B₄

10

f. 4v V₃

Verse 43 1 सौरार] सौरारि M₁M₂ रवेः] x वेः M₁ पुरतः] पुरत IM₂V₄ 2 ग्रहात्स्फुट] ग्रहा(ट)स्फुट V₅ खगो] खगा V₄ एव] एव एव V₄ 3 स्थिते] स्थित R₁ एव] एव[x] V₅ स्त्रयाणां] स्त्रयाणा M₂ 4 पूर्वै] पूर्वै V₃, पूर्वै V₄, corrected from पूर्वै to पूर्वै V₅ श्वलोच्च] [श्व]श्वलोच्च B₅, श्वलोच्च V₄ मिति प्रदिष्टम्] मिति प्रदिष्टः R₁, मिति प्रतिष्ठं V₃, मिह प्रदृष्टं V₅ **Verse 44** 5 मान्दाभावे] मंदाभावे R₁V₅, मं[r]दाभावे V₂, मंदाभावो V₄ तुल्यं] तुल्यं M₁, ह्युल्यं V₃, तुल्ये V₄ 6 खेटं] खेट R₁, corrected from खेटं to खेट V₄ तन्मितिः] तन्मि(F)तः B₄, तन्मि[?]तिः B₅, तन्मितितिः V₄ साधनीया] कल्पनीया IV₂V₄, साधनीया M₃, साधनीयाः R₁ 7 दैत्येज्य] दैत्येज M₁M₂, दैत्येज्य[सा] V₃, corrected from दैत्यैज्य to दैत्येज्य V₅ 8 ज्ञेयौ—साधनीये] om. together with part of verse 45 but added in margin: ज्ञेयौ ताभ्यां तद्गती साधनीये ४४ V₃ ज्ञेयौ] ज्ञेयो M₃ ताभ्यां] ताभ्या R₁ तद्गती] तद्गतीः R₁, तद्गति V₄ साधनीये] साधनीयो R₃ **Verse 45** numbered 44 V₄ 9–10 याव—संस्थौ] om. together with part of verse 44 but added in margin: यावत्कालं सूर्यतो अग्रस्थितौ स्तस्ता[व]व दृष्टौ पृष्ठसंस्थौ V₃ 9 सूर्यतो] corrected from सूर्यतो to सूर्यतो B₅ अग्रस्थितौ] अग्रस्थितो M₁M₃, [x]ग्र[x x x](w तौ स्त) marg,s V₅ स्त] त M₂ 10 स्तावदृष्टौ] स्ताव दृष्टौ M₃R₁, दृष्टौ V₄ पृष्ठसंस्थौ] पृष्ठसंस्थौ R₁ सदा] तदा IR₁V₂V₄ 11 तस्माज्ज्ञेयाः] [४५ ॥] तस्मात्ज्ञेयाः I, तस्मा ज्ञेयाः M₁, तस्माज्ज्ञेयाः M₂, तस्मादज्ञेया M₃, तस्मा[x]दज्ञेया R₁, corrected from तस्माज्ज्ञेयाः to तस्माज्ज्ञेयाः V₄ पर्ययाः] पर्यया R₁ सूर्यचक्रै] सूर्ययसूर्यचक्रै R₁, सूर्यचक्रै R₃ 12 तुल्याः] तुल्य(r)ः B₄, तूल्याः M₃, तुल्या R₁, तुल्यः R₃ साधनार्थं] साधनार्थ B₅M₃V₄

सितोदयाद्यातघटीप्रमाणं
 स्वच्छाययोत्थं गणितेन यस्मात् ।
 तद्भूमिगर्भस्थनरद्युयातं
 तथा घटीयन्त्रसुसाधितं स्वम् ॥ ४६ ॥

अन्तरेण दिनयातयोर्यदा
 योजनानि कुदलोन्मितानि चेत् ।
 किं । तदा द्युनिशनाडिकामितेह
 कक्षिका फलमिहानुपाततः ॥ ४७ ॥

तन्महत्त्वलघुतैक्यखण्डकं
 मध्यमा सितचलोच्चकक्षिका
 भाजिता गगनकक्षिका तया
 शुक्रतुङ्गचलपर्ययोन्मितिः ॥ ४८ ॥

5

f. 3r M₂

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Verse 46 1 सितो] बुधो I दयाद्यात] दया घात with the *akṣara* घा marked and glossed in the margin as घा by s B₄, दयाद्यात V₄ 2 छायायोत्थं] छपयोत्थ R₁, छायायो [x](त्थं)_{marg,s} V₄ यस्मात्] corrected to यस्मात् but unclear what was originally written V₅ 3 तद्भूमि] त (भूमि)_{marg,s} V₅ स्थनरद्युयातं] स्थनरद्युयातं with the *akṣara* द्यु marked and glossed in margin as द्यु by s B₄, स्थ [xxxxxxx]नरद्युयातं I, स्थनरद्युयात R₁, नरद्युयातं V₄ 4 यन्त्र] यं V₄ सुसाधितं] सुसा (f) धतं B₄, सुसाधित R₁ **Verse 47** 5 अन्तरेण] अंतरेणा V₄ दिनयातयो] दिनपातयो M₃, दिनपातयो R₃, दिनयातयो V₄ 6 कुदलो] कुलो M₃, कदलो R₃ न्मितानि] न्नितानि R₁ 7 निश] निशि R₁, नि [f] श V₅ मितेह] मिते R₁, मितैः IM₁M₂ 8 कक्षिका] कक्षया IM₃, कछिका R₁, कक्षका V₂V₄, क (f) क्षका V₅ **Verse 48** 9 न्ह] न्ह [r] B₄ लघु] ल [r] द्यु M₂ 10 मध्यमा सितचलोच्चकक्षिका] मध्यमा ज्चलकक्षिक (r) नया B₄, मध्यमा ज्चलकक्षिकानया IM₃, मध्यमा ज्चलकक्षिकानया M₁M₂R₃V₃, मध्यमा ज्चलकछिका R₁, मध्य [मा ज्] (zz) चलकक्षिकानया V₂, मध्यमा ज्चत्वकक्षिका तया V₄, मध्यम [r] ज्चलक (f) क्षकान्या V₅ 11 कक्षिका] कक्षका IM₃V₂V₄V₅, काक्षिका M₂, कछिका R₁ 11-12 तया शुक्रतुङ्ग] भवेच्छुक्रतुङ्ग B₄R₁R₃, भवेत्सौम्यतुङ्ग I, भवे छुक्रतुल्य M₁M₂, भवे छुक्रतुङ्ग M₃V₃, तया शुक्रतुङ्ग B₅, भवेत्सौक्रतुङ्ग V₂, भवेच्छुक्रतुङ्ग V₄, भवे छुक्रतुङ्ग with छुक्र marked and the variant reading त्सौम्य added in the margin by s V₅

एवमेव बुधशीघ्रपर्यया -
 न्साधयेदिति सुवासना स्मृता ।
 मन्दतुङ्गखगपातपर्ययाः
 पूर्वसूरिवचनेन साधवः ॥ ४९ ॥

f. 4r R₃

। गतिसमुद्भवयातसमागण -
 स्तरणिभि १२ गुणितो गतमासयुक् ।
 खगुण ३० सङ्गुणितः सतिथिः । पृथ -
 ङ्गिगदिताधिकमाससमाहतः ॥ ५० ॥

5 f. 6r V₄

p. 53 R₁

इनदिनाप्तगताधिकमासकै -
 र्गगनवह्नि ३० गुणैः सहितः पृथक् ।
 युगभवामवासरताडितः
 शशिदिनाप्तगतावमशोधितः ॥ ५१ ॥

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Verse 49 1 एवमेव] ए[x]एव V₃ बुध] सित I, marked and the variant reading सित added in the margin by s V₅ 2 न्साधये] न्त्साधये M₂, त्साधये V₄ स्मृता] स्मृता: R₁ 3 तुङ्गखग] तुङ्गखरा V₄ पर्यया:] पर्यया R₁ 4 साधवः] साधव[१] द्रति V₅ **Verse 50** 5 गति] marked and the annotation अथाहर्गणः added in the margin by s B₄ समुद्भव] समद्भव B₅ यात] जात R₁ गण] गम M₂ 6 स्तरणिभि] स्तरणिभि: M₁ भिर्गुणितो] (भिर्गुणि) ²³ marg, s तो V₅ १२] om. B₅ M₃ R₁ V₂ V₃, स्तरणि १२ IR₂, भि in margin by s V₅ गुणितो] गुणिता B₅ मासयुक्] मास (यु²) ^{supl} V₅ 7 ३०] om. B₅ M₃ R₁ V₃, सं ३० गु M₁ सङ्गुणितः] corrected from संगुणितः to संगुणितः V₄ तिथिः] तिथि V₃ पृथ] प्रथ I 8 ङ्गिगदिता] क्निगदिता B₅, क्निगदितो I मास] प्रास V₄, मास १५९३३३६[?] V₅ समाहतः] समाहतात् B₄ B₅ R₃ V₃ V₅, हतात्ततः I, समाहितः M₂ R₁, हतस्ततः V₂ V₄ **Verse 51** verse number added above the line by s V₅ 9 इनदिना] इति दिना R₁, इनदिना १५५५२००००० V₅ 10 र्गगन] र्गग [व] न V₃ वह्नि] वति ३० V₄ ३०] om. B₅ M₂ V₃, गुणैः [३] ३० V₅ गुणैः] गुणै R₁ V₃ पृथक्] प्रथक् R₁ 11 वावम] वाव B₅ वासर] नासर M₁ M₂, वासर [१] २५०८२२५२ V₅ 12 दिना] दिना १६०३०००००० V₅ शोधितः] शोधित [१]: M₁, शोधिता: V₄

द्युमणिमध्यमसावनमानजो
 दिनगणो रविवासरपूर्वकः ।
 क्षयदिनाधिकमासकशेषतो
 ऽधिकतयावयवं हि परित्यजेत् ॥ ५२ ॥

f. 4v B₅

।यातः सौरसमागणो रवि १२ गुणश्चैत्रादिमासान्वित-

5 f. 5v I & f. 38r

V₂

स्त्रिंश ३० द्वः सतिथिर्भवन्ति दिवसाः सौराः पृथक्स्थैस्तु तैः । ।
 संसाध्याधिकमासकान्दिनमयैस्तैर्युक्पृथक्स्थो गण-
 श्चान्द्रः स्यादनुपातजैः क्षयदिनैर्हीनो भवेत्सावनः ॥ ५३ ॥

f. 4v e V₃

f. 14v V₅

स्यात्सौरवत्सरमुखं क्रियसङ्क्रमादौ
 तच्चैत्रमासमुखयोर्विवरे ऽधिशेषम् ।
 त्यक्तेन तेन रविवत्सरवक्तः स्या-
 दह्नां गणो मधुसितादिगतो ऽन्यथासौ ॥ ५४ ॥

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f. 6v V₄

Verse 52 1 मध्य] म[r]ध्य B₄ मानजो] मान[xx]जो B₄, मानतो V₅ 2 गणो] मणो V₃
 वासर] वासस M₂ 3 मासक] मास M₁ शेषतो] शेषतो R₁ 4 यावयवं] यावयवं M₃, याचयवं R₁,
 याव[r]यवं V₅ परित्यजेत्] परित्यजेत्[?] B₅, परित्यजेत् I **Verse 53** 5 यातः] यात B₄, corrected
 from याते: to यात: V₄ रवि] रवि: R₁ १२] om. B₄B₅R₁V₂V₃V₄V₅ दिमा] दिम्मा M₃
 सान्वित] सान्वितो M₂ 6 स्त्रिंश] स्त्रिं ॥ वा R₁ ३०] om. B₄B₅R₃V₅ द्वः] द्व[r]: M₁,
 द्वः M₂M₃V₃; द्व[?]द्वः V₄ सतिथि] स[x]ति[x]थि V₅ भवन्ति] लवन्ति M₂ सौराः] सौ[x]राः
 V₃ पृथक्स्थे] पृथक्स्थे B₄R₃, पृथक्स्थे M₂, पृथक्स्थे V₃, पृथक्स्थे V₄ 7 संसाध्या] साध्येता I, संख्याता V₄
 धिक] दिक् M₃ कृथक्स्थो] स्थे B₅, कृथक्स्थो IR₁, कृथक्स्थो M₃, कृथ x V₄, कृथक्स्थो [xxxxxxxx] V₅
 8 शान्द्रः] शान्द्र M₁M₃, शान्द्रा M₂, श(र)द्रः V₅ जैः] जै R₁ हीनो] हीनो M₁R₃ त्सावनः]
 त्सावन[r]: M₁ **Verse 54** 9 वत्सर] वत्स B₄R₃ मुखं] सुखं V₄ 10 विवरे] विव[x]रे I,
 विवरो R₁ 11 वक्तः] वक्तः B₄M₂M₃R₁V₄, वक्त[?]तः I, वक्त M₁ 12 गणो मधुसितादिगतो ऽन्यथासौ]
 गण(स्तद)marg,s धिको ऽपरथा त्वभीष्टा(त्)marg,s B₄, गणस्तदधिको परथा त्व[r]भीष्टात् B₅, गणो मधुगतादिगतो
 न्यथासौ I, गणस्तदधिको परथा त्वभीष्टात् M₁M₂M₃R₁R₃, गणो मधुसिणदिगतो न्यथासौ V₄, गणस्तदधिको परथा
 त्वभीष्टात् with ण—ष्टात् marked and variant reading णो मधुसितादिगतो न्यथासौ added in margin by
 s V₅

न्यूनाहशेषं तु निशीथमध्य-
तिथ्यन्तयोरन्तरगं सदैव ।
त्यक्तेन तेनेह निशीथकाले
दिवागणो ऽस्माद्ग्रहसाधनं च ॥ ५५ ॥

p. 54 R₁

भगणसङ्गुणितेष्टदिवागणा-
त्फलमिलादिवसैर्वलयादिकम् ।
भवति मध्यरवौ रजनीदले
सति दशा ननपत्तनके ग्रहः ॥ ५६ ॥

5

f. 38v V₂

f. 4v R₃

साङ्गिशक्रशत १४२५ शोधितो भवे-
च्छालिवाहनशको ऽब्दसञ्चयः ।
सङ्गुणः खगगुणेन योजितः
क्षेपकेण शरदि ध्रुवो भवेत् ॥ ५७ ॥

10

Verse 55 1 न्यूनाह] न्यूना [x] (ह)_{marg,s} V₅ शेषं] शेषे V₄ निशीथ] (f)न[१]शीथ I, निशीथं V₄ 2 तिथ्यन्त] तिथ्यत R₁ रन्तरगं] रतरगं B₄, अंतरग I, अंतरगं R₁V₄ सदैव] ददैव B₅ 3 त्यक्तेन तेने] corrected from त्यक्तेन तेने to त्यक्तेन तेने V₅ ह] (ह)_{marg,s} V₅ निशीथ] नि[f]शीथ B₅ काले] कालो I **Verse 56** 5-6 गणात्फल] गणः फल B₄R₁R₃ 6 मिला] भिला V₄ वलया] भगणा V₅ 7 भवति] भवति V₄ रवौ] रतौ M₂ 8 पत्तनके] पट्टणके M₁M₂, पत्तनकै M₃ ग्रहः] गृहः R₁ **Verse 57** not numbered R₁ 9 साङ्गि] स्वाङ्गि M₁M₂, सोङ्गि V₄ १४२५] placed after भवे in *pāda* a IV₂V₄, om. M₃ शोधितो] शोधिते R₁ 10 च्छालि] छाल B₅, छालि IM₂M₃R₁V₂V₅ शको ऽब्द] शब्दो corrected to शब्दा B₅, शर्काब्द M₁, शंको R₁ 11 सङ्गुणः] स गुणः V₄ खग] (ख)_{marg,s}ग V₅ गुणेन] गुणै R₃ योजितः] संस्कृतः IV₂V₄ 12 क्षेपकेण] क्षेपकेन IM₁M₂M₃R₁R₃V₂V₄, क्षेपकेन with the *akṣara* न marked, probably to indicate that the correct *akṣara* is ण V₅ शरदि] marked and glossed as वर्ये by s B₄, शरदिक् V₅ ध्रुवो] ध्रुवो R₁

भादिर्गुणः शशधरे श्रुतयो <४> दिनेशाः <१२>
 षट्सिन्धवो <४६> ऽम्बरयुगा <४०> न्यहि।सागरा <४८> श्व ।
 भौमे रसाः <६> शशिभुवो <११> ऽब्धियमा <२४> नवा <९> ङ्ग <६>-
 वर्गो बुधे ऽथ शशभृ <१> द्युगपक्ष <२४> तुल्याः ॥ ५८ ॥

f. 6r B₄

पञ्चाब्धयो <४५> धृतय <१८> ईज्यगुणस्तु रूपं <१>
 खं <०> भूयमाः <२१> षड <६> थ शुक्रगुणो। महीध्राः <७> ।
 पञ्चेन्दवः <१५> शिव <११> मिता द्विशरा <५२> मतङ्ग-
 वेदाः <४८> शनेः ख <०> मिनसूर्यखबाणसिद्धाः <१२।१२।५०।२४>
 । ५९ ।

5

f. 6r I

इन्द्रूच्चके भूः <१> खभुवः <१०> कुवेदाः <४१>
 खं <०> वेदबाणा <५४> स्तमसो ऽथ शून्यम् <०> ।
 नन्देन्दव। <१९> श्वन्द्रयमा <२१> म।हे।शाः <११>

10

f. 7r V₄, f. 25r M₃,

f. 5r B₅

सिद्धाः <२४> समेशे ऽथ दिनादि।को ऽयम् ॥ ६० ॥

f. 39r V₂

Verse 58 tables listing the contents of verses 58–64 found in B₄B₅IM₃R₃V₂V₄ 1 भादि] corrected from भादि to भादि V₅ धरे] धर M₃ श्रुतयो] श्रुतयो B₅R₁, कृतयो with कृ marked and the reading श्रु given in the margin R₃ शाः] शा(ह्)^{supl} I 2 वो <४६> ऽम्बर] वो वर R₁ युगा <४०> न्यहि] युगाग्न्यहि M₁ 3 भौमे] भौमो M₁ रसाः] रसा R₁ ऽब्धियमा] व्यपमा R₁ नवा <९> ङ्ग] नवां(ऽ)^{supl} R₃ 4 वर्गो] वर्गा V₄ ऽथ] (ऽ)^{supl} थ B₄, य R₃ पक्ष] पक्षे B₅
Verse 59 not numbered V₂ 5 गुण] गुणा M₃R₁, गुण[r] V₅ स्तु] corrected from स्तू to स्तु M₁ 6 षड <६> थ] षडक्ष V₄ गुणो] गुणे V₄ महीध्राः] महीध्रा? B₄, मही[द्रा]ध्राः M₁, महीध्राः M₃ 7 पञ्चेन्दवः] पञ्चेंदवोंदवः B₅ शरा] शरे R₁ मतङ्ग] पतंगे R₁ 8 शनेः] शने B₅ ख <०> मिन] स्वामिन V₄ सिद्धाः] सिद्धा V₄ **Verse 60** 10 भूः] [द्वि]भूः B₄, द्विभूः R₃ वेदाः] वेदा R₁ 11 स्तमसो] स्तमयो R₁ 12 नन्देन्दव] नन्देदव V₄ महेशाः] महेशा R₁ 13 सिद्धाः] सिद्धा R₁ दिना] दि[र्]ना B₄

रूपं <१> पञ्चैके <१५> कुरामाः ३१ कुरामाः <३१>
 सिद्धा <२४> स्तिथ्यादिर्गुणश्चान्द्रशुद्धौ ।
 रुद्रा <४१> रामा <३> रामबाणा <५३> च सिद्धाः <२४>
 कल्पाब्दाप्ताः पर्ययास्ते गुणाः स्युः ॥ ६१ ॥

क्षेपा रवे रसखशक्रमहीध्रवेदा <६।०।१४।४७>
 नन्दा <९> नवेषुदहना <९।३५> द्वियुगानि <४२> चन्द्रे ।
 रूपं <१> त्रयो <३> युगगुणाः <३४> क्षितिजे ऽग्निवेदा <४३>
 बौधे चले ऽर्णवखतत्त्वपुरन्दरा <४।०।२४।१४> च ॥ ६२ ॥

जीवे यमेन्द्रनृपसूर्य <२।१४।१६।१२> मिताः सितोच्चै
 पूर्णेन्दवो <१०> युग <४> मिताः सदलाक्षरामाः <३५।३०> ।
 मन्दे यमौ <२> नवभुवो <१९> द्वियमा <२२> मुनिक्षमा <१७>
 उच्चै नगाद्रिशररामपुरन्दरा <७।७।३५।१४> च ॥ ६३ ॥

5

f. 5r R₃, f. 6v B₄

f. 39v V₂

10

f. 6r beg V₃

Verse 61 1 पञ्चैके] पंचैको? I, पंचैक [r] V₅ कुरामाः ३१ कुरामाः <३१>] कुरामाः कुरामा M₂R₁,
 कुरा रः कुरा माः M₃, कुरा ३१ रः कुरा रः with कुरामाः कुरामाः added in the margin V₂, कु[x]रामाः
 [x](कु)_{marg,s} रामाः V₅ 2 स्तिथ्या] स्तु तिथ्या M₃, corrected from तिथ्या to तिथ्या V₅ गुण] गुण R₁
 चान्द्र] चान्द्र I, चंद्र R₁ शुद्धौ] सिद्धौ B₅ 3 रुद्रा] रुद्रा V₂ रामा] [बाणा]रामा M₁, राम
 R₁ सिद्धाः] सिद्धा R₁ 4 कल्पा—स्युः] om. but कल्पाब्दाप्ताः पर्ययास्ते गुणाः स्युः added in margin
 R₃ कल्पाब्दाप्ताः] कल्पाब्दाप्ता? B₄, कल्पब्दाप्ता R₁, कल्प (r)ब्दाप्ता (r:) V₅ गुणाः] गुणा M₁M₂R₁V₄
Verse 62 numbered 63 M₁M₂, numbered together with *pādas* ab of verse 63 as 63 V₂
 5 क्षेपा] क्षेपो V₅ रस] [र](क्र)_{marg,s} तु where the *akṣara* तु was originally a स B₄ खशक्र]
 खशुक्र M₁M₂, कशक्र M₃ महीध्रवेदा] महीधराख्या M₃R₁ 6 नन्दा] नंद R₁ नवेषु] यवेषु B₄R₃
 दहना द्वि] दहना [x] द्वि I, दहनाद्रि M₂ युगानि] युगानि M₂ 7 रूपं] रूप R₃ युग] गुण I,
 [xx](युग)_{marg,s} V₂ गुणाः] गुणा M₁M₂M₃, गुणः R₁ ऽग्नि] क्षि with this *akṣara* marked and
 variant reading ग्नि added in margin by s V₅ वेदा] वेदा V₄ 8 ऽर्णवख] णव [ख]ख B₅, णवत्ख V₄
 पुरन्दराश्च] पुरंदराख्याः R₁ **Verse 63** om. M₁M₂, *pādas* ab numbered together with
 verse 62 as 62 while *pādas* cd are numbered together with *pādas* ab of verse 64 as 63 V₂,
 numbered 62 V₅ 9 जीवे] जीवे V₄ यमेन्द्र] न्यमेन्द्र R₁ नृप] [नृ]नृप B₅ 10 पूर्णेन्दवो]
 पूर्णेदवो R₁ मिताः] मिता B₅ रामाः] रामा B₄R₃ 11 मन्दे] मन्दे R₁ यमौ] यमो B₄R₃
 नव] [x](न)_{supl} V₅ भुवो] भुवौ M₃R₁V₅ मुनि] [x](मु)_{marg} V₂ 12 उच्चै] उच्चै M₃

पाते ऽम्बरं <०> हर <११> मिता नवराम <३९> सङ्ख्या
 रामेषवः <५३> शरदिने श्रुतयो <४> धृति <१८> श्व ।
 रामेषवः <५३> ख <०> मिति वारमुखो ऽथ शुद्धौ
 तिथ्यादिको । यमनवाञ्चियुगाग्नयः <२ । २९ । ३४> खम् <०> ॥ ६४ ॥

f. 6v I

चैत्रादि।याततिथयो विगतर्तुशुद्धि-

5 f. 15r V₅, f. 5v

B₅

हीनाः समाधिपघटीरहिता दिनौघः ।

वारो ऽब्दपाद्रविसमार्धगणान्तरालं

कल्प्यो दिनौघ इति खेचरसाधनार्थम् ॥ ६५ ॥

f. 7v V₄

Verse 64 *pādas* ab numbered together with *pādas* cd of verse 63 as 63 while *pādas* cd are numbered 64 V₂ 1 पाते] पात M₁M₂ हर] हति R₁, [xx](हर)_{marg,s} V₅ राम] रोंम R₁ सङ्ख्या] सख्या R₁, सं[x](ख्या)_{marg,s} V₅ 2 रामेषवः <५३> शरदिने श्रुतयो <४> धृति <१८> श्व] रामेषवः शरदिन श्रुतयो धृ[स्व](ति)_{marg,s} B₄, रामेषवो थ शरदि श्रुतयो धृतिश्च B₅, रामेष[?]वः शरदिने श्रुतयो धृतिश्च I, रामेषवो थ शरदि श्रुतयो धृतिश्च M₁M₂M₃, रामेषवः शरदिने श्रुतयो धृतिश्च R₁, रामेषवः शरदिन श्रुतयो धृतिश्च R₃, रामेषवो थ (श)_{marg} रदि [x] श्रुतयो धृतिश्च V₂, रामेषवो थ शरदि (तु[?])_{marg,s} श्रुतयो धृतिश्च V₃, रामेषव [r](ः) [x] शरदि(ने)_{marg,s} मुनयो धृतिश्च [r] with मुनयो marked and the variant reading श्रुतयो given in margin by s V₅ 3 ख <०> मिति] खमित R₁, स्वमिरि V₄ वार] चार V₄ मुखो] मुख (r) V₅ शुद्धौ] शुद्धौ V₃ 4 तिथ्यादिको] तिथ्याञ्चिनो R₁ युगाग्नयः <२ । २९ । ३४> खम् <०>] गुणाग्नयश्च B₄, यु[x]गाग्नयश्च B₅, युगाग्नयो यं IM₃R₁V₂, युगाग्नयश्च M₁M₂R₃, युगाग्नयः स्युः V₄, युगाग्नयो यं with यो यं marked and the variant reading यः खं given in the margin by s V₅
Verse 65 5 यात] पात M₃ तिथयो] तितिथयो V₃ विगतर्तु] विगतर्तु V₃V₄, विग[f]र्तु V₅ 5-6 शुद्धिहीनाः] शुद्धिहीनाः M₂, शुद्धिहीनः V₄ 6 समाधिप] समाधिय R₁, समाधिपं V₃ 7 वारो] चा[?]रो[?] B₅ ऽब्दपाद्रवि] ब्दपा १८२ द्रवि B₅, ब्दपा(त्)_{marg} रवि M₁, ब्दपारवि M₃, ब्दपद्रवि R₁ समार्ध] समाद्ध B₅, समार्द्ध १८२ । ३७ B₄, समार्द्ध १८२ । ३७ । ४५ R₃ गणान्त] [xx]गणांत B₄, corrected from गुणांत to गणांत M₃ रालं] रालं १८२ V₂V₄, रालं with १८२ added in the margin by s V₅ 8 कल्प्यो] कल्प्यौ M₂, कल्पो ३७ ४५ ३७ ४५
 M₃, कल्पो R₁, कल्पे V₄, corrected from कल्प्ये to कल्प्यो V₅ इति] इह B₅M₁M₂M₃V₂V₃V₄V₅, इति[x] I

द्युप्रौघः। स्वगगनष ६० ड्लवेन हीनो
 रव्यंशा निजनग ७ भागलिसिकाद्धाः ।
 वेदा ४ सद्युचयविलिसिको नितास्ते
 खेटानां फलमिनगोलयोर्ऋण स्वम् ॥ ६६ ॥

p. 56 R₁

f. 3r M₁

दिनगणो गुणचन्द्र १३। गुणः पृथ-
 ग्दश १० गुणो। नगवह्निनगो ७३७ द्यूतः ।
 फलयुतः स विधुर्लवपूर्वको
 दिनगणाहि ८ लवोनविलिसिकः ॥ ६७ ॥

5 f. 7r B₄

f. 40r V₂

निजनिशाकरनेत्र २१ लवान्वितं
 दिनगणस्य दलं लवपूर्वकः ।
 विचरणद्युगणेन च संयुतं
 विकलिकासु भवेत्क्षितिनन्दनः ॥ ६८ ॥

10

Verse 66 1 द्युप्रौघः] थ^२प्रौघः V₅ ६०] षड् ६० लवेन B₄R₃, om. B₅M₃R₁V₃V₄V₅, षड्लवेन
 ६० IV₃, षड्ल ६० वेन M₁ वेन] वे [f]न V₅ हीनो] हीनो ३७ (the numerals obviously belong
 ४५

with the previous verse, but were copied here by the scribe) B₅ 2 रव्यंशा] रव्यंश (r) V₅
 नग] गज R₁ ७] om. B₅IM₃R₁V₂V₃V₄V₅ लिसिका] लिसका B₄ द्धाः] द्धाः? B₄, द्धाः
 M₃R₁R₃V₄, द्धाः marked and the variant reading द्धाः added in the margin by s V₅ 3 ४]
 om. B₅M₃R₁V₂V₃V₅ स] [x](स)_{margin} V₂, स्त V₄ चय] त्रय M₂ विलिसि] विलि (f)स
 V₅ कोनितास्ते] को [x]नकास्ते B₅, कोनितास्ते: M₁, कोनकाष्टै: M₂, कोनकास्ते V₂, को (f)न [r]तास्ते V₅
 4 खेटानां] खेत्तनां with त्त marked and the variant reading टा added in margin V₃ फल] कल R₃
 गोलयोर्ऋण] गोलयो ऋण B₄B₅IM₃R₁R₃V₃V₄V₅, गोर्ऋण M₁M₂, गोलयो: ऋ^२ण with ऋ^२ marked and
 glossed as ऋ in the margin (most likely to make the reading clear) V₂ **Verse 67**
 numbered 167 V₄ 5 गणो] गनो R₁, गुणो V₅ गुणचन्द्र] गुणो गुणचंद्र V₄ १३] om.
 B₅IM₃R₁V₃V₅ गुणः] हतः B₄R₃ 6 १०] om. M₃R₁V₃V₅ गुणो] corrected from गुणे to
 गुणो B₄, गुणे R₃ वह्नि] चह्नि V₃ ७३७] om. B₅IM₃R₁V₂V₃V₅ 7 युतः] युत्तः V₃ 8 दिन]
 दिण V₄ गणाहि] गणो हि R₁ ८] om. B₄M₁R₁R₃V₃ विलिसिकः] विलिसकः M₃, विलिसिका
 R₁, विलिसिक [r]: V₅ **Verse 68** 9 कर] क [r]र V₃ २१] om. B₅IM₃R₁V₂V₃V₅, २२ M₂
 लवान्वितं] लवान्विते V₄ 10 पूर्वकः] पूर्वकः? B₄, पूर्वक IR₁V₂V₄, पूर्वकः M₂ 11 विचरण] विचरण ४
 B₄R₃ द्युगणेन] द्युदलेन V₄ च संयुतं] समन्वितं R₁ 12 विकलिकासु] षि^२कलिकासु B₄, corrected
 from विकलिकाशु to विकलिकासु V₅ भवेत्क्षिति] भवे (त्)_{margin}, क्षिति B₄, भवे क्षिति IR₃V₅

द्युगणसङ्गुणितार्णव ४ सम्मिति-

f. 8r V₄, f. 5v R₃

बुधचलोच्चलवाः खशरा ५० हतात् ।

द्युगणतो नव ९ लब्धकलान्विता

विकलििकासु गणेन च शोधिताः ॥ ६९ ॥

f. 6v V₃

दिनगणस्त्रि ३ गुणो नख २० भाजितो

5

दिनगणात्पतितो विकला ऋणम् ।

f. 7r I

शर ५ समाहतवासरसञ्चयो-

न्मितकलादि पुरन्दरपूजिते ॥ ७० ॥

सितचले ऽर्कफलं स्वदलान्वितं

गतशता १०० शगणाष्ट ८ लवेन युक् ।

10

खगुण ३० हृद्युगणो लवपूर्वको

p. 57 R₁

गणखभूप १६० लवाद्यकलः शनिः ॥ ७१ ॥

f. 40v V₂

Verse 69 1 गण] गुण M₁M₂M₃, ग^२ण V₅ तार्णव] तार्णवः M₁ ४] om. B₅M₃R₁V₂V₃V₄V₅
2 चलोच्च] चलं च B₄R₃ लवाः] ल[r]वाः V₄ खशरा] खरारा R₁ ५०] om. B₅IM₃R₁V₃V₅
हतात्] हताः V₅ 3 गण] corrected from गुण to गण B₅ नव] न[x]व I ९] om. B₅V₃V₅,
नव^१ V₂ कलान्विता] कलान्विता M₁ 4 विकलििकासु गणेन च शोधिताः] विकलिकासुगणेन विशोधिता R₁
शोधिताः] शोधितः R₃, शोधिताः V₃ **Verse 70** numbered 7 V₄ 5 गणस्त्रि] गण[x]
with स्त्रि following as an insert written between markers in the line below M₃ ३] om.
B₅M₃R₁V₂ गुणो] corrected from गेणो to गुणो M₃, corrected from गुणे to गुणो V₅ २०] om.
B₅M₃R₁V₃V₅, नख^२ I 6 गणा] गणा V₄ विकला] विकला[सु] I ऋणम्] रु^२णं V₂, ऋणम्: V₄
7 ५] om. B₅IM₃R₁V₂V₃V₄ समाहत] समहत R₃ वासर] वासरं V₄ 8 कलादि] कला हि
M₁M₂R₃, कलादि R₁ पूजिते] corrected from पूजिते to पूजितः V₅ **Verse 71** numbered
70 V₂ 9 चले] चरे M₁M₂ फलं] पलं V₄ स्व] (स्व)_{marg} M₁ 10 गत] गण R₁ १००]
om. B₅M₁M₂M₃R₁R₃V₃V₅ ८] om. B₅M₁M₂M₃R₁R₃V₃, गणाष्ट^५ V₅ 11 गुण] गुण[r] M₁
३०] om. R₁V₃ हृद्यु] हृद्यु B₄, हृ(त्)_{marg,s}द्यु V₅ गणो] गणे B₄R₃, गुणो M₁ 12 १६०]
om. B₅M₃V₃ लवाद्यकलः] लवोन[xx]कलः I, लवाद्यकलः M₃, लवाद्यफलः R₁, लवोनकलः corrected to
लवाद्यकलः and with लवाद्यकलः added in the margin as well V₂, लवाद्यकलः with वाद्य marked and
the variant reading वोन given in the margin by s V₅

दशा १० सो दिनौघो लवाद्यं विधूच्चं
स्वकीयत्रि ३ भागोनिताहर्गणेन ।
कुवेदां ४१ शयुक्तेन युक्तं कलासु
क्रमायातमब्जस्य पातं प्रवक्ष्ये ॥ ७२ ॥

दि १० ग्गुणितस्त्रि ३ हतो दिनसङ्घः
स्वाकृति २२ भागवियुक्कलिकाद्यम् ।
चन्द्रतमः स्वफलेन युतोनाः
स्वध्रुवका उदये |द्युचराः |स्युः ॥ ७३ ॥

5

f. 6r B₄, f. 7r B₄

अज्ञातग्रहभुक्त्या
विज्ञातग्रहमितिर्गुणिता ।
ज्ञातग्रहभुक्तिहता
ल|ब्धमविज्ञातखेटः स्यात् ॥ ७४ ॥

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f. 8v V₄

Verse 72 1 १०] om. B₄B₅M₃R₁R₃V₃V₅, दशासो १० I सो] सौ M₁ दिनौघो]
दिनौ[x](घो)_{marg,s} B₄ विधूच्चं] वि[x]धूच्चं B₄, निधूच्चं M₂ 2 स्वकीयत्रि] स्वकीयं त्रि R₁, स्वकीयस्त्रि V₄
३] om. B₅IM₁M₂M₃R₁V₂V₃V₄V₅ निता] हता M₁M₂ हर्ग] [x](ह)_{marg,s} V₅ 3 ४१]
om. B₅IV₂, कुवेदांश ४१ V₃V₄, कुवेदांश^{४१} V₅ 4 क्रमा—क्ष्ये] प्रपात्यं शतं सार्द्धमुच्चं च पाते I, प्रयोज्यं शतं
सार्द्धमुच्चं च पाते but this is marked and the variant reading क्रमाज्जा^१पत्ते^२ वजस्य पातं प्रवक्ष्ये is added
in the margin V₂, प्रयोज्यं शतं सार्द्धमुच्चं च पाते V₄ क्रमाया] corrected from क्रमायो to क्रमाया V₅
Verse 73 5 १०] om. B₅IM₃R₁V₂V₃V₅, placed between ग्गु and णित V₄ ग्गुणित] ग्गुणि[x]त
M₃, corrected from ग्गु to ग्गुणित V₄ ३] om. B₅IM₃R₁V₂V₃V₅ 6 स्वाकृति] स्व(र)कृति
B₄, स्वा[x]कृति I, स्वकृति R₃ २२] om. IM₁M₃R₁V₂V₃V₅, २^२ V₄ वियुक्क] वियुतः क B₄R₃
काद्यम्] काद्य B₄ 7 तमः] तम M₁ स्वफलेन] सफलन M₁ युतोनाः] युतोना IV₂ 8 स्वध्रुवका]
स्वध्रुवका: B₅, स्वध्रुवा R₁ उदये द्युचराः] द्युचरा उदये B₄R₃, उदये द्युद्युचरा: with f. 6r ending after the
first द्यु B₅, उदये खचरा I, उदये द्युचरा M₁M₂, उदये खचरा: V₂V₄ **Verse 74** numbered first
75 but corrected to 74 M₁, numbered 75 M₂ before the verse M₁ and M₂ inserts: अत्र
रविभगणाः ५ चंद्रभ ७ भूदिनं २७ द्युगुणः संगुणिनेष्टदिवागणादित्यादिना साधितौ ग्रहौ तन्मध्यमे ज्ञाताज्ञातकल्पनेति (M₂
has तन्ममे instead of तन्मध्यमे) 9 ग्रह] ग्र V₄ 10 विज्ञात] [xxx]विज्ञा(त)_{marg} M₃ ग्रहमिति]
ग्रमिति M₁, ग्रगति V₄ 11 ज्ञात] ज्ञान M₂, विज्ञात V₅ हता] हता M₃ 12 मविज्ञात] मतिज्ञात R₁
खेटः] खेटः [x] B₄, खेट M₁

अलब्धो ऽधिमासः स्फुटो लभ्यते चे -
 तदा खत्रि ३० वृद्धा हि शुद्धिर्विशुद्धा ।
 ततः साधनीयो ऽब्दमध्ये दिनौघः
 प्रयाताधिमासास्तदा रूप १ हीनाः ॥ ७५ ॥

सूर्यसङ्क्रमसम्पर्का -
 च्छशिमासस्य शुद्धता ।
 तद्वियोगादशुद्धत्व -
 अधिकत्वं च जायते ॥ ७६ ॥

5 f. 32r M₃

f. 7v I, f. 41r V₂

f. 7r V₃

मेषार्कसङ्क्रमो यत्र
 चान्द्रमासे प्रजायते ।
 स मासो मधुसङ्गः स्या -
 न्माधवाद्या वृषादिभिः ॥ ७७ ॥

10

f. 15v V₅

Verse 75 numbered 75 V₄ 1 अलब्धो] अलब्धा B₄, अल[x]ब्धो I, अलोब्धो M₁ स्फुटो]
 corrected from स्फुटो to स्फुटो V₃, फुटो V₄ 2 तदा] तदा[r] B₅ ३०] om. B₅IM₃R₁V₃V₅
 वृद्धा हि] वृद्धा हि IM₃V₂, वृद्धा वि V₄, वृ[द्धा² हि](द्धा वि) marg,s V₅ शुद्धिर्विशुद्धा] शुद्धिर्विभक्ता B₄M₃R₃,
 शुद्धिविधेया R₁, शुद्धिर्विशुद्धा V₃ 3 ततः] corrected from तत्तः to ततः V₃ दिनौघः] [x]दिनौघः V₃
 4 प्रयाता] corrected from प्रयात्ता to प्रयाता V₃ मासास्तदा] मासाःस्तदा M₃, मासास्तादा V₄ १] om.
 B₄B₅IM₃R₁R₃V₂V₃V₄V₅ **Verse 76** 5 सूर्य] [x]सूर्य B₄ सङ्क्रम] संक्रम R₁ सम्पर्का]
 संपर्क(r) B₄, सम्पर्क R₃ 6 च्छशि] च्छशि R₃ मास] मास[r] V₃ शुद्धता] शुद्धता V₃ 7 तद्वि]
 corrected from तद्वि to तद्वि V₃ दशुद्धत्व] शु[x](द्ध) marg,s V₅ 8 त्वं] त्वे V₄ **Verse 77**
 numbered 78 and placed after verse 79 IV₄, placed after verse 79 V₂ 9 मेषार्क] मेषार्कः M₁
 10 चान्द्रमासे] मासे चांद्रे V₂ प्रजायते] मजायते V₄ 11 सङ्गः] (सं)^{supl} I, संज्ञ M₁, संज्ञ M₂R₁, सं x
 कः M₃ स्या] स्य(r) V₅ 12 न्माधवाद्या] न्मा www V₅

चान्द्रैर्द्वादश १२ मा।सकैश्च तिथिभिः श्रीकण्ठ ११ सङ्ख्यैस्तथा
 नाडीभिस्त्रिभि ३ रग्निसायक ५३ पलैः स्यात्सौ।रवर्षं यतः ।
 एकस्मिन्नविवत्सरे यदधिकं ।स्यादब्दवृद्ध्या ततो
 मासैः सार्धरदोन्मितैरधिकमास्त्रिंशत्तिथिर्मध्यमः ॥ ७८ ॥

p. 58 R₁

f. 6r R₃

f. 41v V₂, f. 4r M₂

Verse 78 numbered 79 and with a different second half (see apparatus) and placed after verse 77 IV₄, numbered 78 and with a different second half and placed after verse 77 V₂, second half of verse marked as not belonging in his other manuscript and different second half inserted in margin and renumbered as 79 by s V₅ 1 चान्द्रैर्द्वादश] चंद्रैर्द्वादश M₃, चांद्रैर्द्वादश R₁ १२] see next *pāda* B₄M₁M₂M₃R₁R₃, om. B₅V₃V₄V₅, कै १२ च I तिथिभिः] तिथि[ये]भिः M₁ ११] see end of next *pāda* B₄M₁M₂M₃R₁R₃, om. IV₂V₄V₅ सङ्ख्यैस्तथा] संज्ञैस्तथा B₄R₃, संख्यैस्तथा (r) V₅ 2 स्त्रिभिरग्निसायक] स्त्रिभिरश्चिसायक I, स्तिसृभिस्त्रिसायक R₁V₂V₄, with भिरग्निसायक marked and the variant reading स्तिसृभिस्त्रि added in the margin R₃, with रग्नि marked and the variant reading च added in the margin by s V₅ ३] see later this *pāda* B₄M₁M₂M₃R₁R₃, om. B₅IV₃V₄ ५३] see after पलैः B₄M₃R₁R₃, ५२ I, see end of the *pāda* M₁M₂, ३ V₅ पलैः] पलैः १२।११।३।५३ B₄, लै ३७१ M₃, पलैः ३७१।३।५३।२४ R₁, पलैः १२२।११।३।५३ R₃, पलैः wwwwww
 ३
 ५३
 २४

V₅ स्यात्सौर] सयात्सौर M₃ यतः] ततः I, यतः १२।११।३।५३ M₁, यतः १।२।११।५।५३ M₂ 3-4 एकस्मि—मध्यमः] संक्रांतिद्वयसंयुतो दिनगतो मासक्षयो सौ यदा भुक्ति स्यान्महती स चेत्प्रतिपदारम्भे च तत्संक्रमः I, found combined with verse 83 (see there) but as second half of this verse is संक्रांतिद्वयसंयुतो निगदितो मासः क्षयो सौ यदा भुक्तिः स्यान्महती स चेत्प्रतिपदारम्भे च तत्संक्रमः V₂, संक्रांतिद्वयसंयुतो निगदितो मासः क्षयो सौ यदा भुक्तिः स्या [(f. 9r V₄) न्महती स चेत्प्रतिपदारम्भे च तत्संक्रमः V₄, originally this is second half of the verse but s has marked this as not found in his other manuscripts and inserted संक्रांतिद्वयसंयुतो निगदितो मासः क्षयो सौ यदा भुक्तिः स्यान्महती स चेत्प्रतिपदारम्भे च तत्संक्रमः in the margin combining it with *pādas* ab as a verse 79 V₅ 3 एकस्मिन्नवि] एकस्मि रवि M₁ वत्सरे] वत्सरे M₂, चत्सरे V₃ यदधिकं] यदधिक B₅ दब्दवृद्ध्या] दष्टवृद्ध्या M₁M₂, दब्दवृद्ध्या M₃V₅, दब्दपृद्ध्या V₂ 4 सार्धरदोन्मितै] सार्द्धरदो ३२।१६ [x] न्मितै B₄, सार्धरदोन्मितैः ३२।१५ M₁, सार्धरदोन्मितै ३२।१५ M₂, सार्द्धरदो ३२।१६ न्मितै R₃ मास्त्रिंश] मा[x]स्त्रिंश B₄, corrected from मोस्त्रिंश to मास्त्रिंश B₅, मास्त्रिंश R₃ मध्यमः] मध्यमाः V₅

एकं चेदवनीदिनं दिनमणेः स्यान्मध्यगत्या तदा
 राशौ किं रविमासको ऽथ हिमकृन्मासस्तु गत्यन्तरे ।
 एकं स्याद्रविसावनं यदि तदा चक्रे किमेवं विधो-
 मासादभ्यधिको रवेरधिकमास्तत्सार्धदन्तोन्मितैः ॥ ७९ ॥

दर्शाग्रतो मण्डलनाडिकान्तं
 मासः स सूर्येन्दुसमागमान्तः ।
 तदन्तरे चेद्रविसङ्क्रमः स्या-
 त्तदा स शुद्धस्त्वधिको ऽन्यथा सौ ॥ ८० ॥

5 f. 8r B₄

इदं यदुक्तं क्षितिगर्भगाणां
 कुपृष्ठगानामथ सम्प्रवक्ष्ये ।
 यः साधितो दर्शविरामकालः
 स्फुटो भवेल्लम्बनसंस्कृतो ऽत्र ॥ ८१ ॥

10

Verse 79 numbered 77 and placed between verse 76 and verse 77 IV₄, numbered 76 and placed between verse 76 and verse 77 V₂, combined with second half of last verse and renumbered as 78 by s V₅ 1 चेदवनी] चेद(र)वनी with वनी marked and the annotation भूदिनं added in the margin by s B₄ दिनमणेः] दिनमणे M₁ गत्या] गत्या M₁ तदा] तथा M₁ 2 मासको] मासके M₁M₂ ऽथ] (ऽ)^{supl,s} B₄ गत्यन्तरे] गत्यन्तरे R₃, गत्यन्तरे V₅ 3 किमेवं] किमे [f] वं V₃ 4 मासा] मासा २९ । ३१ । ६ I, मासा २९ । ३१ । ५० V₂V₄, मासा (२९ । ३१ । ५) ^{marg,s} (after ५ the rest of the margin is cut off due to copying process) V₅ दभ्यधिको] दभ्याधिका R₁ रधिकमास्तत्सा] रधिमस्तत्सा M₁, रधिकमात्सा M₂, रधिकमाः स्यात्सा with स्या marked and the variant reading सा added in the margin V₂, रधिकमाः स्यात्सा V₄ दन्तोन्मितैः] दंतोन्मितैः (ः)^{supl} ३२ । १६ B₄, दंतोन्मितैः ३२ । १५ M₁M₂, [x]दंतोन्मितैः V₂V₅, दंतोन्मितैः ३२ ११ ५१ V₄ **Verse 80** given in the margin B₄, om. I, given in the margin with no variants with the given text V₂, placed before verse 81 V₄ 5 दर्शाग्रतो] दर्शततो B₄, राशिं गतो M₁M₂, दर्शान्ततो R₃, दश्यतो V₄ मण्डलनाडिकान्तं] मंडल (ना) ^{marg} डिकांतं V₃, मंडलनाडीकांतं V₄, मंड (ल) ^{marg,s} V₅ 6 मासः] मासैः V₃ सूर्येन्दु] सूर्येडु V₃ समागमान्तः] समोतः V₄ 7 चेद्रवि] चेद्रवि M₃R₁, चंद्रवि V₄ सङ्क्रमः] संक्रम M₁, संक्रमं M₂, संक्रम M₃, संक्रम R₁ स्या] न्या M₃ 8 स्त्वधिको] x धिको B₅ ऽन्यथा] न्यथा M₃ **Verse 81** om. I numbered 82 R₁, in margin but mainly illegible due to copying process V₂, erased in main text but added again in margin and numbered 81 by s without variants from given text V₅ 9 इदं] इयं M₂ यदुक्तं] य(डु) ^{subl} क्तं B₅, मदुक्तं M₃ गर्भगाणां] गर्भगानां R₁, गर्भगाणां V₃, गर्भगणां V₄ 10 कुपृष्ठ] कुपृ [x] (ष्ट) ^{marg,s} B₄, कुपृष्ठ R₁, कुपृष्टा V₃, corrected from कुपृष्ट to कुपृष्ठ V₄ 11 साधितो] साधिता M₃ 12 स्फुटो] स्फु [त्तो] (टो) ^{marg} V₃

यतः स्फुटे दर्शविरामकाले
दृक्सूत्रसंस्थौ रविशीतरश्मी ।
कुपृष्ठगानामथ निश्चयेन
स्यातां हि तद्गोलविदो वदन्ति ॥ ८२ ॥

f. 6v B₅

खाभ्रखाभ्राष्टभूमि १८०००० गतं यत्कले -
स्तष्टमेतस्य यातैष्ययोरल्पकम् ।

5 f. 8r I

तद्गुवा १ पावकैः ३ सिद्ध २४ सङ्घौ २४ हंतं
दृग्यमैः २२ खाग्निभिः ३० खाङ्ककै १० रद्विभिः ७ ॥ ८३ ॥

f. 7v V₃

Verse 82 om. I, in the margin without variants from the given text V₂, given between
verse 83 and verse 84 and renumbered 83 by s V₅ 1 यतः] यतः V₅ 2 रश्मी] रश्मि
M₁ 3 कुपृष्ठ] कुपृष्ठ] [गा]पृष्ठ B₅ मथ] मिति M₃ 4 स्यातां हि] स्यात्तर्हि M₁M₂, स्यातां हि
R₃ वदन्ति] वन्दन्ति R₃, विदन्ति V₃ **Verse 83** numbered 80 and placed after verse
79 I, numbered 81 M₃, not numbered V₂, placed before verse 82 V₅ 5 खाभ्र] खाभ्र V₅
खाभ्राष्ट] खाष्ट V₃ 5-6 भूमि—अल्पकम्] भूतष्ट १८०००० यातं कलेः शेषयातैष्ययोयद्भवेदल्पकं I 5 भूमि] भूमि
M₁M₃R₁ १८००००] om. B₅M₃R₁V₃, भिर्गतं १८०००० V₂, भू १८०००० भि V₅ 6 स्तष्टमे] तष्टये V₄
तस्य] marked and the annotation कलि added in the margin by s B₄ यातैष्य] स्यातैष्य with स्या
marked and the variant reading या added in the margin V₃ योरल्पकम्] योर (५)^{supl}ल्पकं B₄,
7 तद्गुवा] तद्गुवैः १ V₄ १] om. B₅M₃V₂V₃, तद्गुवा I ३] om. B₅M₃V₂V₃, पावकैः I २४] om.
B₅M₃V₂V₃, सिद्ध I 7-8 २४—दृग्यमैः] om. V₄ 7 हंतं] हंतं [प्रवक्ष्ये यः साधितो दर्शविरामकालः स्फुटो
भवेत्तद्वनसंस्कृतो व xx] V₅ 8 दृग्यमैः] दृग्यमै R₁ २२] om. B₅M₃V₃ खाग्निभिः] खाग्निभि R₁
३०] om. B₅M₃V₃ खाङ्ककै] खाङ्ककै [वं? xx] R₁ १०] om. M₃V₃, खाङ्ककै I रद्विभिः ७] वद्विभिः
B₅, वद्विभिः ३ M₁M₂, रद्विभिः M₃, रद्विभि ७ R₁, रद्विभिः ७ R₃, चद्विभिः V₃, रद्विभिः यु V₄ after the
verse is an annotation in the margin चंद्रोच्चे षष्टि ६० गुणितं फलं धनं । चंद्रपाते त्रिंशत् ३० गुणितं फलं ऋणं ।
एवं दृक्समं भवति I

नन्दनिघ्नायुतेना १०००० सभागैर्युताः
सूर्यसौरावनीजाः परे वर्जिताः ।
दृक्समत्वं ग्रहाणामनेन स्फुटं
प्राह दामोदराचार्य एवं बुधः ॥ ८४ ॥

लङ्कातः शरसूर्य १२५ योजनगता कन्याथ कान्ती रदैः ३२
स्वामी खाष्ट ८० मितैर्नखै २० स्तु सगरो मल्लारिरक्षेन्दुभिः १५ ।
पर्यल्यष्टभि ८ रुत्तरत्र दशभिः १० स्याद्वत्सगुल्मं पुरं
खाक्षै ५० रुज्जयिनीपुरं दशकुभि ११० स्तस्मात्कुरुक्षेत्रकम् ॥ ८५ ॥

5 f. 9v V₄

f. 6v R₃, f. 41v e V₂

Verse 84 numbered 81 I, numbered 82 M₃, placed after verse 79 but not numbered V₂, placed after verse 82 and not numbered but numbering given as 83 by sV₅ before the verse क्षेपकौ २ V₅ 1 नन्द] नंद १ R₃ निघ्नायुतेना] marked and the annotation १०००० added in the margin by s B₄ १००००] om. B₅M₃V₃, तेनात् १०००० IV₂, ८०००० M₂, (१००००)_{marg,s} V₅ भागैर्युताः] भागैर्युताः M₁, भोगैर्युताः M₃, भागैर्युताः V₃ 2 सौरावनीजाः] सौरावनीजाः M₃, सौरावनीया R₁ परे वर्जिताः] परे वर्जिताः with परे marked and the annotation चंद्रबुधगुरुशुक्र[?] added in the margin by s B₄, परे वर्जिता I, परैर्वर्जिताः R₁ 3 ग्रहाणामनेन] ग्रहाणामनेन M₁V₄ स्फुटं] [प्राह] स्फुटं I, स्फुलं M₁, स्फुट V₄ 4 एवं] एकं B₅, खं R₁ **Verse 85** numbered 82 I, numbered 83 M₃, numbered 80 V₂, not numbered V₄, not numbered but numbering given as 83 by s V₅ 5 लङ्कातः] corrected from लङ्कावः to लङ्कातः V₅ १२५] om. B₅IV₃, योजन १२५ M₃V₅ गता] गतौ V₃ कन्याथ कान्ती रदैः ३२] स्यादेवकन्या ततः IV₂V₄, marked and the variant reading स्यादेवकन्या ततः added in margin by s V₅ कान्ती] कांथी B₄, कांत (१) V₃ रदैः] रदैः with कैः marked and the reading दैः added in margin V₃ ३२] रदैः^{३२} B₄B₅, om. R₃V₃ 6 खाष्ट] षाष्ट with षा marked with two half-circles above it V₅ ८०] खाष्ट^{८०} B₅, om. IV₂V₃, मितै ८० M₂ मितै] corrected from मितौ to मितै V₃ नखै] नखै (:) ^{supl}[x] I, नखै M₂ २०] नखै^{२०} B₅, om. IM₃R₁V₂V₃, स्तु २० M₁, सगरो २० V₅ स्तु सगरो] सुसगरो I, स्तु सगरो V₃ मल्लारि] मल्लारि M₃, मल्लारि R₃ १५] अक्षे^{१५}दुभिः B₅, om. IR₁V₂V₃ 7 पर्यल्य] पर्यल्य with व्यं marked and the variant reading ज्जं added in margin by s B₄ ८] ल्यष्ट^८ B₅, om. IR₁V₂V₃, ल्यष्ट ८ V₅ रुत्तर] रु[x](त्त) ^{supl,s}र V₅ ३ दश] त्रु दश R₃, प्रदश R₁, स्र दश V₄ १०] दश^{१०} B₅, om. IR₁V₂ स्याद्वत्स] श्रीवत्स IV₂V₃V₄, स्या [xxx]द्वत्स R₃ गुल्मं] गुल्वं M₃R₁ पुरं] ततः IV₂V₃V₄, पर marked and with the variant reading ततः added in margin by s V₅ ८ ५०] खाक्षै^{५०} B₅, om. IM₃R₁V₂V₃ रुज्जयिनी] रुज्जयनी M₁V₂V₅ कुभि] कुभि[x] V₅ ११०] दश कु १० B₄R₃, om. B₅IR₁V₂V₃ स्तस्मा] तस्मा M₁

तस्मान्मे |र्योर्जनैस्तत्त्वनागै ८२५
रेवं भूमेर्मध्यरेखा निरुक्ता ॥ ८६ ॥

f. 8v B₄

रेखापुरस्वनगरान्तरयोजनाख्यैः
खेचारिणां |दिनगतिर्गुणिता विभक्ता ।
स्पष्टे |न भूपरिधिनाप्तकला धनर्ण
मध्यग्रहे निजपुरे ऽपरपूर्व |संस्थे ॥ ८७ ॥

f. 3v M₁

5 f. 16r V₅

p. 60 R₁

स्वपुरसुरनगान्तर्योर्जनैर्यो |जनैः स्या -
त्परिधिरवनिगोले कल्पितः प्रस्फुटो ऽसौ ।
अवनिपरिधिमानं लम्बजीवाविनिघ्नं
त्रिभवनगुणभक्तं तस्य मानं निरुक्तम् ॥ ८८ ॥

f. 8v I

10

Verse 86 not numbered B₅M₁M₂M₃R₁R₃V₃, numbered 83 I, numbered 85 V₄,
numbered 83 V₅ 1 तस्मा | स्तस्मा M₁ योर्जनैस्तत्त्वनागै ८२५ | योर्जनैस्तत्त्वनागैः ८२५ with
नैस्तत्त्वनागैः ८२५ marked and the variant reading नैः खाभ्रनागै ८०० added in margin by s V₅
योर्जनै | योर्जनैः M₁ स्तत्त्व | स्तत्त्व B₄B₅IM₁M₂M₃R₁R₃V₃ नागै | corrected from नागै to नागै
V₃ ८२५ | om. IR₁V₃V₄, added in margin R₃ 2 रेवं भू | रेवमूमे R₁, रैवं भू V₄ मध्य | मध्ये B₅
Verse 87 numbered 86 B₅M₁M₂R₁V₃, numbered 85 I, numbered 84 M₃, numbered 87
R₃V₄, numbered 84 V₅ placed after verse 88 IV₄ 3 पुर | पुरः I योजना | योजना V₃
4 गुणिता | गुणिता M₂ 5 स्पष्टेन | स्पष्टे [न xx]न V₅ नाप्त | ना [त्]प्त I धनर्ण | धनर्णा I 6 पुरे |
corrected from पुरे to पुरे V₄ संस्थे | संस्थे? V₃ **Verse 88** numbered 87 B₅M₁M₂R₁V₃,
numbered 84 I, numbered 85 M₃V₅, numbered 88 R₃, numbered 86 V₄ placed before
verse 87 IV₄ 7 सुरनगान्त | सुरं नगांत B₅ सुरनगांत with नगांत marked and the annotation सुमेरु
added in the margin by s R₃, न [r](गां)_{marg,s} V₅ योर्जनैर्योर्जनैः | योर्जनैर्योर्जनैः IR₁, र्यो[?]जनर्योर्जनैः?
M₃, योर्जनै [:] (योर्जनैः)_{marg,s} V₅ स्या | स्य (r) V₃ 8 रवनि | कनि M₁, खनि R₁ गोले | गा[?]ले M₃
कल्पितः प्रस्फुटो | कल्पित (:)_{supl} प्रस्फुटो B₄, प्रस्फुटः कल्पितो R₁ 9 जीवा | जीचा V₃ विनिघ्नं | निघ्नं V₄
10 त्रिभवन | marked and the annotation त्रिज्यया added in the margin by s B₄, त्रिभनव I, त्रिभुवन
R₁, त्रिस[?]भवन V₄, corrected from त्रिभुवन to त्रिभवन V₄ गुण | गुण (३४३८)_{marg,s} V₅

प्रोक्ता मयातिसुगमा न समीरितान्यै-
 र्या वासनाकृतिषु विस्तृतिशङ्कयेह ।
 सङ्क्षिप्य यद्वहु विहाय पिबन्ति सारं
 स्वल्पं सुधांशुवल्यं विबुधा रसज्ञाः ॥ ८९ ॥

। इत्थं श्रीमन्नागनाथात्मजे । न

5 f. 10r V₄, f. 7r

B₅

प्रोक्ते । तन्त्रे ज्ञानराजेन रम्ये ।
 ग्रन्थागाराधारभूते प्रभूते
 सूर्यादीनां मध्यमानं निरुक्तम् ॥ ९० ॥

f. 7v e V₃

Verse 89 numbered 88 B₅R₁V₃V₄, numbered 86 IM₃V₅, numbered 87 M₁M₂ 1 प्रोक्ता]
 उक्ता IV₄ मयाति] मयान I, मयात्र V₄ 1-2 सुगमा न समीरितान्यैर्या] सुगमा न समीरिता [x] (द्यै) marg.s या
 B₄, सुगमा न समीरिताद्यैर्या B₅M₁R₃, सुगमा न समीरितान्यैर्वा IV₂V₄, सुगमा निसमीरिताद्यैर्या M₂, सुगमा
 न समीरिताद्यैर्या V₃, सुगमा न समीरितान्यैर्या with न समीरितान्यैर्या marked and the variant reading
 न्यसमीरिता वा या added in the margin by s V₅ 2 विस्तृतिशङ्कयेह] त्रिस्तृति शंकयेह B₄R₃, विस्
 तृतिशंकयेहा M₁M₂, विस्तृतिशंकयेह M₃, विस्तृतिशंकयेह R₁, विस्तृतिशंकयेह V₃, विस्तृतिशंकयेह V₄ 3 सङ्क्षिप्य
 यद्वहु] भूमंडलं बहु IV₂V₄, संक्षिप्य यद्वहु with संक्षिप्य यद्व marked and the variant reading भूमंडलं
 ब added in the margin by s V₅ सारं] सौरं B₄B₅M₁M₂M₃R₁R₃V₃, corrected from सारं
 to सारं V₄, सौरं with सौ marked and the variant reading सा added in the margin by s
 V₅ 4 सुधांशु] शुधांशु V₂V₄V₅, सुधांश R₁, सुधाशु V₃ रसज्ञाः] रसज्ञा V₃, corrected from
 रसुज्ञाः to रसज्ञाः V₄ **Verse 90** numbered 89 B₅R₁V₃V₄, numbered 87 IM₃V₅,
 numbered 88 M₁M₂ 6-7 प्रोक्ते—प्रभूते] om. V₅ 6 प्रोक्ते] प्रोक्तं M₃ 7 धार]
 दार R₁ प्रभूते] प्रभूते [प्रभूते] I 8 दीनां] दीना R₁ मानं निरुक्तम्] मा भुक्तिरुक्ता B₄R₃,
 मानां निरुक्तं M₁M₂ **Colophon** (इति श्रीनागराजात्मजज्ञानराजविरचिते सिद्धांतसुंदरे गणिताध्याये
 मध्यमाधिकारः प्रथमः) marg.s) B₄, इति इति श्रीमन्नागनाथात्मजज्ञानराजविरचिते सिद्धांतसुंदरे मध्यमाधिकारः
 संपूर्णः B₅, इति सकलसिद्धांतवासनाविचारचतुरचित्तचमत्कारकारिणि सिद्धांतसुंदरे मध्य [x] ग्रहानयनाधिकारः प्रथमः
 I, इति श्रीमन्नागनाथात्मजज्ञानराजविरचिते सकलसिद्धांतवासनाविचारचंचुरचित्तचमत्कृतिकारिणि सतंत्राधारे सिद्धांतसुंदरे
 मध्यमाधिकारः प्रथमः संपूर्णः M₁, इति श्रीमन्नागनाथात्मजज्ञानराजाविरचिते सकलसिद्धांतवासनाविचारचंचुर-
 चित्तचमत्कृतिकारिणि सतंत्राधारे सिद्धांतसुंदरे मध्यमाधिकारः प्रथमः संपूर्णः M₂, इति श्रीमत्सकलसिद्धांत-
 वासनाविचारचतुरचंचुरतरापरशास्त्ररहस्याभिजदज्ञज्ञानराजग्रथितसिद्धांतसुंदरवासनाभाष्यसूजनविचक्षणेकभूष्ये ज्ञानाधिराज-
 सूनूपंडितचित्तामणिविरचिते ग्रहगणितचिंतामणौ मध्यगतिसाधनाधिकारः समाप्तः (colophon for Cintāmaṇi's
 commentary) M₃, om. R₁, om. R₃, इति श्रीसकलसिद्धांतसुंदरे मध्यमग्रहानयनाधिकारः प्रथमः V₄, om.
 V₅

⟨अथ ग्रहगणिताध्याये स्पष्टाधिकारः⟩

।अथ जननविधानयानपाणि -

f. 9r I

ग्रहणमुखेष्वखिलेषु मङ्गलेषु ।

स्फुटतरखचरैः ।फलं प्रधानं

f. 4v M₂

स्फुटमत एव वदामि तद्विधानम् ॥ १॥

5

पञ्चाकृतयो २२५ नवाब्धिवेदा ४४९

भूशैलर्तु ६७१ मिताः खनन्दनागाः ८९० ।

बाणाभ्रभवाः ११०५ शरेन्दुविश्वे १३१५

विंशत्यक्षभुवो १५२० ऽङ्कभूहयक्ष्माः १७१९ ॥ २॥

chapter opens अथ स्पष्टाधिकारः B₅ Verse 1 2 जनन] जननि M₃, जन V₄ यान] यात M₃
पाणि] पाणिपदा V₄ 3 मङ्गलेषु] मंगलेषु [मंगलेषु] V₅ 4 फलं] फल V₅ 5 वदामि] (व)_{marg,s}
R₃ Verse 2 tables listing the contents of verses 2–5 found in B₅IM₃R₂R₃V₂V₄V₅
6 पञ्चाकृतयो] पंचा[x](कृ)_{marg}तयो I, पेचाकृहतेयोर V₄ २२५] om. B₄B₅IM₁M₂M₃R₁R₃V₅, २५ V₄
४४९] om. B₄B₅IM₁M₂M₃R₁R₃V₅ 7 भूशैलर्तु] भूलौ [र]लर्तुं M₁, भूरौलर्तुं M₂, भूशैलर्तुं M₃, भूथैलर्तुं
V₄, भूशैलभर्तुं V₅ ६७१] om. B₄B₅IM₁M₂M₃R₁R₃V₅, मिताः ६७१ V₄ मिताः] मिता R₁ नन्द]
दंत M₁M₂, नंग M₃ नागाः] नागा(:)_{supl} B₄, भागाः V₄ ८९०] om. B₄B₅IM₁M₂M₃R₁R₃V₅
8 बाणा] बाण I भवाः] शिवाः IV₄, [x](शि)_{marg,s}वाः V₅ ११०५] om. B₄B₅IM₁M₂M₃R₁R₃V₅
१३१५] om. B₄B₅IM₁M₂M₃R₁R₃V₅ 9 विंशत्य] विंशत्य B₄R₃, विंश(त्य)_{marg} I, दीशत्य M₃ १५२०]
om. B₄B₅IM₁M₂M₃R₁R₃V₅, १५२० V₄ ऽङ्क] क्ष R₁, क V₄ भू] भूत V₄ हय] [न]हय[x]
B₄, (ह)_{marg}य I, हयय R₃, नंग V₄V₅ १७१९] om. B₄B₅IM₁M₂M₃R₁R₃V₅

आशाङ्कभुव १९१० स्त्रिगोऽभ्रपक्षाः २०९३

f. 8v ends B₄ & f. 9r

R₂

सप्तर्त्वा|कृतयः २२६७ कुरामसिद्धाः २४३१ ।

p. 61 R₁

भूतेभशराश्विनो २५८५ ऽर्धजीवाः

पिण्डक्षाणि २७२८ नवाक्षपिण्ड २८५९ सङ्ख्याः ॥ ३ ॥

वस्वद्रिनवाश्विनो २९७८ ऽब्धिनाग -

5

त्रिंश ३०८४ |च्छैलनगेन्दुरामसङ्ख्याः ३१७७ ।

f. 10v V₄

अ|ङ्गेषुरदाः ३२५६ कुदस्रदेवाः ३३२१

f. 7r, 7v R₃

पक्षाद्रि त्रिगुणाः ३३७२ क्रमेण जीवाः ॥ ४ ॥

गोऽभ्राब्धिगुणाः ३४०९ कुवह्निवेद -

लोका ३४३१ मङ्गलवह्निवेदरामाः ३४३८ ।

10

आसां तु विलोमतो ऽन्तरैकौ -

स्तु|ल्याः स्युर्विपरीतमौर्विकाख्याः ॥ ५ ॥

f. 11r V₄

Verse 3 1 आशाङ्कभुव] आशांक[r]भुवे M₃ १९१०] om. B₅IM₁M₂M₃R₁R₂R₃V₅, corrected from १११० to १९१० V₄ स्त्रिगोऽभ्र] स्त्रयोभ्र R₂, स्त्रियोत्र R₃ पक्षाः] पक्षा R₁ २०९३] om. B₅IM₁M₂M₃R₁R₂R₃V₅ 2 सप्तर्त्वा] सप्तत्वा M₃ २२६७] om. B₅IM₁M₂M₃R₁R₂R₃V₅ २४३१] om. B₅IM₁M₂M₃R₁R₂R₃V₅ 3 भूतेभ] भूतेभु B₅, भूतेश R₁, भूताष्ट V₄ शराश्विनो] शर[r]द्विना I, शरेंद्विनो R₁ २५८५] om. B₅IM₁M₂M₃R₁R₂R₃V₅ ऽर्ध] corrected from ऽर्ध to ऽर्ध V₅ जीवाः] जीवा B₅V₅ 4 पिण्ड] पि(ङ)_{marg,s} R₂ क्षाणि] क्षाणि V₄ २७२८] om. B₅IM₁M₂M₃R₁R₂R₃V₅, corrected from २७२९ to २७२८ V₄ नवाक्ष] नवानवाक्ष M₁M₂ २८५९] om. B₅IM₁M₂M₃R₁R₂R₃V₅, संख्याः २८५९ V₄ सङ्ख्याः] संख्या M₁ **Verse 4** 5 द्रिनवा] द्रिद्रिनवा V₄ २९७८] om. B₅M₁M₂M₃R₁R₂R₃V₅ नाग] नागा M₃ 6 ३०८४] om. B₅M₁M₂M₃R₁R₂R₃V₅ च्छैल] छैल marked and variant reading त्पंच given in the margin by s V₅ नगेन्दु] नखेंदु M₃, नगैदु R₃ सङ्ख्याः] संख्याः R₁ ३१७७] om. B₅M₁M₂M₃R₁R₂R₃V₅ 7 अङ्गेषु] अङ्गकेत् अ[r]गेषु V₄ रदाः] रदा R₁, रदा(:)_{supl} V₅ ३२५६] om. B₅IM₁M₂M₃R₁R₂R₃V₅ दस्र] दस्र [v] B₅, दस्र [x] V₅ देवाः] देवा R₁ ३३२१] om. B₅IM₁M₂M₃R₁R₂R₃V₅ 8 गुणाः] गुण R₁, गुणा V₄ ३३७२] om. B₅IM₁M₂M₃R₁R₂R₃V₅ **Verse 5** 9 गुणाः] गुणा(:)_{supl} I ३४०९] om. B₅IM₁M₂M₃R₁R₂R₃V₅ वह्निवेद] corrected from वंह्निवेद to वह्निवेद B₅, वह्निदेव M₁, वेदवह्नि M₂ 10 ३४३१] om. B₅IM₁M₂M₃R₁R₂R₃V₅ वह्निवेद] रामवेद I, वह्निदेव M₁M₂, वेदराम R₁, रामवेद [xxx] V₅ ३४३८] om. B₅IM₁M₂M₃R₁R₂R₃V₅ 11 आसां] आशां R₂ तु विलोमतो] वि तु लोमतो B₅ रैकौ] रैकौ R₂R₃, रैकै V₄ 12 स्तुल्याः] स्तुल्या IM₃R₁, तुल्या M₁M₂ ख्याः] ख्या M₃R₂R₃

वृत्ते चक्रकलायुते परिधिषण्णन्दां १६ शकैरङ्किते
 प्राग्नेखोभयचिह्नयोरुपरिगा जीवा विधेयाः क्रमात् ।
 ताः स्युस्तत्र गजाब्धिभिः ४८ परिमितास्तत्रैव तासां धनू-
 ष्याचिन्त्यानि धनुर्गुणान्तरगता ज्ञेयोत्क्रमज्या तथ ॥ ६ ॥

f. 43r b V₂, f. 9v I

f. 16v V₅

आद्यं खण्डं भगणकलिकाषण्णवत्यं १६ शतुल्यं
 बाहुः कर्णस्त्रिभवनगुणः कोटिराभ्यामियं चेत् ।
 त्रिज्याकर्णे भवति शरदृङ्गेत्र २२५ तुल्ये किमेवं
 लब्धं स्थूलं प्रथमपरयोर्जीवयोरन्तरालम् ॥ ७ ॥

5 f. 7v B₅

f. 8r B₅

Verse 6 not numbered V₂ before verse अत्रोपपत्तिः in margin by s R₂ 1 कलायुते] कलायते B₅M₁M₂, दलायते M₂, कलांकिते R₁, कलांकिते २१६०० R₂, कला २१६०० यते with कला corrected from कलो R₃ १६] om. B₅IM₁M₂M₃R₁V₂V₅, शकै १६ V₄ रङ्किते] रंकिते (:) ^{supl} I 2 प्राग्नेखो] प्राग्नेखो R₃, प्राग्नेखो V₂ रुपरिगा] रापरिगा M₁, अपरिगा M₂, रुपरिगा: M₃ 3 ताः] ता IM₁M₂M₃R₁ ४८] om. B₅M₁M₂M₃R₁, गजाब्धि ४८ भिः V₂, गजाब्धिभिः ^{४८} V₅ तासां] तासा M₂ धनू] धनुं B₅M₁, धनु M₃R₁ 4 ष्या] व्या B₅ चिन्त्यानि] चिंतानि M₃, चिंत्याद्य with द्य marked and variant reading नि noted in margin by s V₅ **Verse 7** not numbered V₂ 5 कलिका] कलि [x] (लि) ^{supl,s} का V₅ १६] om. B₅IM₃R₁R₃V₂V₅, त्यंश १६ M₁ शतुल्यं] शतुल्यं २२५ I, om. M₂, श २२५ तुल्यं V₄, श (२२५) ^{marg,s} तुल्यं R₂ 6 बाहुः] बाहुः M₁M₂, बाहु R₁ कर्णस्त्रि] कर्ण [x] स्त्रि I, कर्णः स्त्रि M₁, कर्णस्त्री M₃, कर्णस्ति V₄ भवन] भुवन R₁, corrected from भुवन to भवन V₅ गुणः] गुण M₃, गुणः ३४३८ IV₂V₄, गुणः (३४३८) ^{marg,s} V₅ कोटि] को (टि) ^{marg} I 7 कर्णे] करणे M₁, तुल्ये marked and the variant reading कर्णे added in margin by s R₂, तुल्ये R₃ भवति] नवति R₃ शर] शर [x] V₅ २२५] om. B₅M₃R₁R₂R₃V₅, ३२५ M₂, तु (ल्ये) ^{marg} २२५ I, तुल्ये (२२५) ^{supl,s} V₅ तुल्ये] तु (ल्ये) ^{marg} I 8 लब्धं] corrected from लब्धं to लब्धं M₁ परयो] पस्यो M₃, [x] परय (र) V₅ जीव] जीव M₁ रन्तरालम्] रंत [r] (रा) ^{marg,s} लं V₅

कोटिर्दि १० गघ्री त्रितिथि १५३ विहृता जायते चा|न्त|रालं
तत्संयुक्तात्प्रथमदलतः स्याद्वितीयं तथैवम् ।
यद्यातैष्यान्तरयुतिदलं ज्यान्तरं तत्स्फुटं स्या-
देवं सर्वाण्यपि गुणदलान्युद्भवन्ति क्रमेण ॥ ८ ॥

p. 62 R₁, f. 8v B₅

|यो मूल|मौर्वीदलतो ऽखिलानि
जीवादला|न्यानयति क्रमेण ।
मन्यामहे तं गणितज्ञचक्र-
भ|चक्रचाराकलने ध्रुवेन्द्रम् ॥ ९ ॥

5 f. 10r I, f. 43v V₂

f. 10r R₂

पदानि चत्वारि सराशिवृत्ते
मुख्ये पदे ज्योपचयः क्रियादेः ।
भवेद्वितीये ऽपचयस्तृतीये
वृद्धिश्चतुर्थे ऽपचयो भुजे च ॥ १० ॥

10

Verse 8 not numbered V₂ 1 कोटिर्दि] कोटिर्दि B₅, कोटिर्दि I, १०] om. B₅M₁M₂M₃R₁,
दिङ्घी १० I, दिङ्घी १० V₄ गघ्री] कघ्री B₅, घ्री IM₁M₂R₁R₂V₂ तिथि] तिथी M₁, थि V₄ १५३] om.
B₅M₁M₂M₃R₁V₅ विहृता] विहृती I, विवृता V₄ चान्तरालं] वां [x]तराल I 2 तत्सं] त सं V₄
त्वथम] (त्) marg,s प्रथम R₂, प्रथम V₄ दलतः] दलत [r](:) B₅ स्याद्वितीयं तथैवम्] स्या द्वितीयं तथैवं
B₅, सा [x]ध्य भूयोतरं वा I, स्या द्वितीयं तथैव M₃, स्याद्वितीयं तथैव R₂R₃, स्या धितीयं तथैव R₁, साध्य भूयोतरं
वा marked and with the variant reading स्या द्वितीयं तथैव added in margin V₂, साध्यो भूयोतरं वा
V₄, स्या द्वितीयं तथैवं marked and the variant reading साध्य भूयोतरं वा added in margin by s V₅
3 यद्यातै] यद्यांत्यै B₅, यद्य (r)तै R₂, यद्यतै R₃ दलं] द (लं) marg I, दल M₁M₂R₃ 4 देवं] देयं M₂
सर्वाण्यपि] सर्वान्यपि R₁ गुण] गुल M₁ दलान्यु] दलाद्यु M₁, दलाद्यु M₂, दलात्यु M₃, दमलान्यु R₁,
दलास्यु R₃ **Verse 9** 5 यो] यौ V₄ मौर्वी] दो वी M₁ दलतो] दलता M₃ ऽखिलानि]
खलानि M₂ 6 जीवा] जिवा B₅ क्रमेण] कृमेण V₅ 7 महे] हते I 8 भचक्र] om. M₂
चारा] चारा B₅, चाला M₂, तारा R₂R₃V₅, x रा V₄ कलने] कल [x]ने I, कलै M₁, कलनै M₂, कलनैः V₄
ध्रुवेन्द्रम्] corrected from ध्रुवों x द्र to ध्रुवेन्द्र I, ध्रुवेन्द्र R₃, ध्रुवेन्द्र V₅ **Verse 10** numbered 11 V₂
9 सराशिवृत्ते] marked and the annotation अक्रांतिवृत्ते added in margin B₅, च राशिवृत्ते R₂R₃,
सराशि (वृत्ते) marg V₂ 10 मुख्ये पदे] marked and the annotation प्रथमपदे added in margin by
s R₂ ज्योपचयः] चोपचयः R₃ क्रियादेः] क्रियादे (:) R₂, क्रियादे R₃ 11 भवेद्वितीये] भवे द्वितीये
B₅IM₂M₃R₁V₅, प (दे) marg,another R₂, खेद्वितीये R₃ ऽपचय] ज्यचय B₅, ऽए^२चय R₃ स्तृतीये]
स्तृ [x]तीये I, स्त्रितीये R₁ 12 चतुर्थे] चतु [x](थै) marg,s V₅ ऽपचयो भुजे च] ऽपचयोभुजे च B₅, पचयो
भुजे [x] च I, पचयो भुजस्य R₂R₃, पंचयो भुजे च V₄, corrected from पचयै to पचये V₅

भुजांशकोना नवति १० स्तु कोटि-
 स्तयोः कलाः पञ्चयमाश्चि २२५ भक्ताः ।
 फलोन्मिता ज्या विगतैष्यजीवा-
 न्तरघ्नशेषाद्धरलब्धयुक्स्यात् ॥ ११ ॥

जीवां विशोध्य शरनेत्रयम २२५ घ्नशेषा-
 |द्यातैष्यखण्डविवरेण हृतात्फलं यत् ।
 यावत्तमाभवति |शोधितमौर्विका त-
 त्सङ्ख्याहताक्षनयनाश्चि २२५ युतं धनुः स्यात् ॥ १२ ॥

5 f. 10v I

f. 8r R₃

|शराक्षीणि <२५> सिद्धा <२४> स्त्रिदस्राः <२३> कुदस्रा <२१>
 नवाङ्का <१९> नृपा <१६> स्त्रीन्दवः <१३> खेन्दव <१०> |श्च ।
 |तथाङ्गानि <६> रामा <३> लघुज्यान्तराणि
 भुजांशा नवा ९ सा गतज्याथ शेषम् ॥ १३ ॥

f. 17v V₅

10 p. 63 R₁

f. 9r B₅ & f. 44r V₂

Verse 11 numbered 12 V₂, numbered 13 M₃ 1 कोना] को M₁, कोन M₂ १०] om.
 B₅IM₃R₁V₂V₄V₅ स्तु] om. M₁ 2 स्तयोः] स्तयो V₄ कलाः] कला R₁ २२५] om.
 B₅M₁M₂M₃R₁, मोश्चि V₅ 3 फलोन्मिता] फलोन्मित[र] I, corrected from फलोन्मितो to फलोन्मिता
 M₃ विगतैष्य] विग[x]तैष्य V₂ 4 शेषाद्धर] शेषाद्धेर I युक्स्यात्] यु[क् x]क्स्यात् I, युक्त्वात् M₁M₂,
 युक्स्य(र)त् R₂ **Verse 12** numbered 13 M₃ 5 जीवां] जीवा M₁M₂ शोध्य] om. V₄
 शर] तर M₁M₂ यम] मय M₂ २२५] om. B₅IM₁M₂R₁V₅ शेषा] वोषा V₄ 6 द्यातै] पातै R₁
 खण्ड] षंड V₅ विवरेण] विवरेणा V₄ 7 भवति शोधित] शो धि भे व ति त M₁ मौर्विका] मौर्विका M₃
 8 हताक्षनय] हता[f]क्ष[f]नय V₅ नाश्चि] ना[x]श्चि M₃ २२५] om. B₅IR₁V₂, corrected from ३२५
 to २२५ V₄, २२५ written beneath नाश्चि by s V₅ धनुः] धनु R₁, धनु(:)supl R₂ **Verse 13**
 numbered 14 IM₃V₂ 9 सिद्धा] om. M₃ कुदस्रा] कुदस्राः M₁M₃, कुदस्राः कुदस्रा V₄
 10 नवाङ्का] नवांका IR₁V₂V₄, नवांक[?] M₃, नवेद्व V₅ नृपा] नृपाण M₂ स्त्रीन्दवः] स्त्रीदवः M₁, स्त्रीदवः
 M₂ खेन्दव] खेदव M₃ 11 तथाङ्गानि] तथागानि M₁ रामा] रामा २५।२४।२३।२१।१९।१६।१३।१०।
 ६।३ I, रामाः V₂ लघु] लघु V₄ राणि] राणि २५।२४।२३।२१।१९।१६।१३।१०।६।३ B₅, २५।२४।
 २३।२१।१९।१६।१३।१०।६।३ M₃R₁V₂, राणि २५।२४।२३।२१।१६।१३।१०।६।३ M₁M₂, २५।२४।२३।२१।
 १९।१६।१३।१०।६।३ V₄, २५।२४।२३।२१।१६।१३।१०।६।३ V₅ 12 भुजांशा] भुजज्या R₁, भुजांश(र) R₂
 ९] om. B₅IM₃R₁V₂V₃V₄V₅ गत] गत R₁ शेषम्] शेष R₁

अयाताहतं गो ९ हृतं यातखण्डै-
 र्युतं ज्या भवेदत्र खण्डानि जह्यात् ।
 नव ९ घ्रावशेषादयाताप्तलब्धं
 विशुद्धाङ्गनिघ्राङ्क ९ युक्तं ।धनुः स्यात् ॥ १४ ॥

f. 12r V₄

मान्दं केन्द्रं मन्दतुङ्गोनखेटः
 शीघ्रं केन्द्रं शीघ्रतुङ्गं खगोनम् ।
 शीघ्रे स्वर्णं मेषजूकादिसंस्थे
 स्वर्णं मान्दे ऽस्वं धनं स्वं फलं स्यात् ॥ १५ ॥

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Verse 14 numbered 15 IM₃V₂ 1 अयाता] अजाता R₁, आयाता V₄ ९] om.
 B₅IM₃R₁V₂V₄V₅ हृतं] (हृ)marg,s V₅ 2 र्युतं ज्या] युतं ज्या M₃, र्युत ज्या R₃ 3 ९]
 om. B₅IM₃R₁V₂V₄V₅ घ्रावशेषा] घ्राविशेषा M₂, घ्रादशेषा M₃, घ्राच्च शेष R₂R₃ याताप्त] जाताप्त
 R₁, याताप्त M₂M₃, याताप्त with त marked and the variant reading च added in margin by s V₅
 4 विशुद्धाङ्क] विशुद्धक R₁, विशुद्धाक R₃ निघ्राङ्क] निघ्राक M₃, निघ्राक V₄ ९] om. B₅IM₃R₁V₂V₄V₅
 धनुः] धनु(:)^{supl} R₂ **Verse 15** numbered 15 IM₃V₂ 5 मान्दं] मादं [तुंगं] B₅
 केन्द्रं] केद्रं R₃ मन्द] मंद R₁ तुङ्गोन] तुंगेन M₁, तुंगेन M₂, तुंगेन R₁ खेटः] खेटा: M₂, खेट(:)^{supl}
 R₂ 6 शीघ्रं] corrected from शैघ्रं to शैघ्र्यं R₂, शैघ्रं R₃ केन्द्रं शीघ्रं] added in margin I, केद्रं शीघ्र
 M₂R₃, केद्रं शीघ्रग M₃ तुङ्गं] तुगं R₁R₂ खगोनम्] खगेरनं V₅ 7 शीघ्रे] शीघ्रो M₃, शैघ्रे R₂R₃
 8 मान्दे] मादं M₃R₁ ऽस्वं धनं स्वं] व्यत्ययात्स्वं V₂, ऽस्व धनस्वं M₃, (ऽ)^{supl}स्वं धनं स्वं V₅

मार्तण्डस्य मृदूच्चनीचवलये शक्राः १४ परिध्यंशकाः

शीतांशोर्दशनाः ३२ कुजे शरनगाः ७५ सौम्ये खरामां ३० शकाः ।

गीर्वाणेन्द्रगुरोः सुरा ३३ दिनकराः १२ शुक्रस्य तानाः ४९ शनेः

केन्द्रे युग्मपदान्ता ओजपदगे वित्र्यंशशक्रा १३ । ४० रवेः ॥ १६ ॥

f. 5r M₂, f. 8v R₃

त्र्यंशोनाः शशिनो रदाः ३१ । ४० क्षितिसुतान्नेत्राद्रयो ७२ ऽष्टाश्विनो २८

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दृग्वह्नि । ३२ प्रमितास्तु शङ्कर ११ मिता मातङ्गवेदाः ४८ क्रमात् ।

f. 11r I

भौमाच्चञ्चलनीचतुङ्गवलये भागाः शराग्न्यश्विनो २३५

f. 4r M₁, p. 64 R₁

गीर्वाणेन्दु १३३ मिता नभोनग ७० समाः पक्षाङ्गनेत्रो २६२ न्मिताः ॥

१७ ॥

Verse 16 numbered 17 IM₃V₂ tables listing the contents of verses 16–18 found in R₂R₃ 1 मार्तण्डस्य] तण्डस्य V₄ मृदू] corrected from मृदु to मृदू V₅ वलये शक्राः] between वलये and शक्राः is भागाः शरा enclosed in brackets to indicate deletion M₁, वलये शक्रः V₄ १४] om. B₅M₁M₂M₃R₁R₂R₃, placed after परिध्यंशकाः IV₂ 2 दंशनाः] दंशनाः M₁M₂, रदहनाः M₃, दंशना R₁, दंशना R₂ ३२] om. B₅M₁M₂M₃R₁R₂R₃ नगाः] नगा V₄ ७५] om. B₅M₁M₂M₃R₁R₂R₃ सौम्ये] साम्ये R₁ ३०] om. B₅M₁M₂M₃R₁R₂R₃, placed at the end of the *pāda* IV₂V₅, x ° V₄ 3 गुरोः] गुरोः B₅, गुरो R₁ सुरा] सुरा M₂, सुराः V₂ ३३] om. B₅M₁M₂M₃R₁R₂R₃, corrected from ३२ to ३३ V₅ १२] om. B₅M₁M₂M₃R₁R₂R₃V₅ तानाः] ताना M₁M₂, ताना (:) _{subl} ४९] om. B₅M₁M₂M₃R₁R₂R₃V₄, शनेः I, ताना (:) _{subl} V₅ 4 केन्द्रे युग्मपदान्ता ओजपदगे] केन्द्रे षट्प्रमिते दिवाकरमिते ईः न्द्रषट्प्रमिते दिवाकर १२ मिते V₄ ओज] ऊज V₂ वित्र्यंश] त्र्यंशोन V₄ १३ । ४०] om. B₅M₁M₂M₃R₁R₂R₃, १३ placed after the verse number I, ४०

१३ । ४० शक्रा V₂V₅ रवेः] om. V₄ **Verse 17** numbered 18 IM₃V₂ 5 त्र्यंशोनाः] अंशोना R₂, अंशोनाः R₃ रदाः] दराः M₁M₂, रदा R₁ ३१ । ४०] om. B₅M₁M₂M₃R₁R₂R₃, ३१ I, ३१ ४० V₄, ४०

३१ । ४० रदाः] with the numerals added by s V₅ द्रयो] दयो B₅ ७२] om. B₅M₁M₂M₃R₁R₂R₃, ७२ द्रयो] with the numerals added by s V₅ श्विनो] corrected from श्विनो to श्विनो V₄ २८] om. B₅M₁M₂M₃R₁R₂R₃, श्विनो V₅ 6–7 दृग्वह्नि — श्विनो २३५] om. but added in margin by s दृग्वह्निप्रमिता ३२ स्तु शंकर ११ मिता मातङ्गवेदाः ४८ क्रमात् ॥ भौमाच्चञ्चलतुङ्गनीचवलये भागाः शराग्न्यश्विनो २३५ V₅ 6 दृग्वह्नि] दावह्नि R₂, दिग्वह्नि M₁M₂, दृग्वह्नि R₃ ३२] om. B₅M₁M₂M₃R₁R₂R₃, प्रमिता ३२ I शङ्कर] शंकर B₅, शंकर V₄ ११] om. B₅M₁M₂M₃R₁R₂R₃, रमिता ११ V₄ मातङ्ग] मातङ्ग V₄ वेदाः] वेदा (:) _{supl} R₂ ४८] om. B₅M₁M₂M₃R₁R₂R₃, क्रमात् ४० V₂ 7 भौमा] भौमो I, भौम M₃ नीचतुङ्ग] तुङ्गनीच V₂, तुङ्गनीच V₄ वलये] वल [x] ये I, वलयो M₃ भागाः] भागा R₁ शरा] शर V₄ २३५] om. B₅M₁M₂M₃R₁R₂R₃, corrected from ३३५ to २३५ V₄ 8 १३३] om. B₅M₁M₂M₃R₁R₂R₃, मिता १३३ I, ण्डु with the numerals added by s V₅ मिता] मिताः M₃ ७०] om. B₅M₁M₂M₃R₁R₂R₃, नग V₂, समा ७० V₄, नग with the numerals added by s V₅ समाः] समा R₁ पक्षाङ्ग] पक्षाग I, पक्षाग [x] M₃ २६२] om. B₅M₁M₂M₃R₁R₂R₃, न्मिताः २६२ IV₂V₄, न्मिताः V₅

गोरामा ३९ इति युग्मके ऽथ विषमे भौमाद्वि।वह्न्यश्विनो २३२
दन्तक्षमा १३२ यमपर्वता ७२ गगनषण्नेत्राणि २६० पूर्णाब्धयः ४० ।
दोज्या केन्द्रभवाहता निजपरीणाहान्तरेणाहता
व्यासार्धेन फलोनयुक्परिधयस्त्वोजाधिकोनाः स्फुटाः ॥ १८ ॥

f. 9v B₅

f. 12v V₄

स्फुटपरिधिगुणे स्वकोटिदोज्ये
भलवहते निजकोटिदोःफले स्तः ।
मृदुभुजफलकार्मुकं हि मान्दं
भवति फलं कलिकामयं ग्रहस्य ॥ १९ ॥

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Verse 18 numbered 19 IM₃V₂ 1 ३९] om. B₅M₁M₂M₃R₁R₂R₃, गोरोमा with the numerals added by s V₅ युग्मके ऽथ विषमे] षण्मते थ रविभे I, षण्मते थ रवि V₄ भौमाद्वि] भौमाद्वि I, भौमादि M₂M₃R₁, corrected from भौमोद्वि to भौमाद्वि V₂, भौमाद्वि V₄ वह्न्यश्विनो] वह्न्यश्विनो B₅, वह्न्य V₂, वह्न्यश्विनो V₄ २३२] om. B₅M₁M₂M₃R₁R₂R₃, श्विनो with the numerals added by s V₅ 2 १३२] om. B₅M₁M₂M₃R₁R₂R₃, क्षमा V₅ 2-4 ता ७२—व्यासार्धेन] om. R₂R₃ 2 पर्वता] पुर्वता M₂ ७२] om. B₅M₁M₂M₃R₁, पर्वता with the numerals added by s V₅ २६०] om. B₅M₁M₂M₃R₁, त्रा २६० णि I, त्राणि with the numerals added by s V₅ पूर्णा] पूर्वा M₁ ४०] om. B₅M₁M₂M₃R₁, ष्यः V₂, same with the numerals added by s V₅ 3 केन्द्रभवा] न्प्रभवा V₄ हता] हता M₁M₂ रेणाहता] रेणा [x] हता V₅ 4 व्यासा] व्याव्यासा B₅ धेन] धेन ३४३८ I, धेत [३४३८] V₂, धेन ३४३८ V₄ फलोन—स्फुटाः] फलोनिताः परिधयः षड्भोदिताः स्युः स्फुटाः IV₄ फलोन] फल (r) न V₅ स्त्वोजाधि] corrected from स्त्वोजोधि to स्त्वोजाधि V₅ कोनाः] कोणाः R₁, कोना (:) ^{supl} R₂ स्फुटाः] परे B₅M₁M₂M₃R₁R₂R₃V₃V₅ **Verse 19** numbered 20 IM₃V₂ 5 गुणे] गुमे R₁ 6 भलवहते निज] भगणलवैनिज I, भलव ३६० हते निज M₁M₂R₂, फलवहते निज M₃, भलव ३६० हते निज R₃, भलवहते निज V₅ दोः] दो (:) ^{supl} R₂ 7 मान्दं] मंदि R₁, मा [x] (दं) ^{marg} R₂, मानं R₃ 8 भवति] भव M₂ फलं] फल M₃ मयं] मयं [हि मादं] V₂, added in margin by s V₅

यद्वा लघुकेन्द्रदोज्या
वेदा ४ हता सप्तरसै ६७ विभक्ता ।
फलं कलाद्यं परिधिघ्नमेवं
सुखार्थमेतन्मृदुसञ्ज्ञकं स्यात् ॥ २० ॥

त्रिज्याशुकोटिफलयोर्मृगकर्कटादौ
केन्द्रे क्रमेण युतिरन्तरकं विधेयम् ।
तद्वर्गबाहुफलवर्गयुतेश्च मूलं
कर्णः कुगर्भखचरान्तरसम्मितः स्यात् ॥ २१ ॥

आसन्नमूलेन हतात्स्ववर्गा-
ल्लब्धेन मूलं सहितं द्विभक्तम् ।
भवेत्तदासन्नपदं ततो ऽपि
मुहुर्मुहुः स्यात्स्फुटमूलमेवम् ॥ २२ ॥

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10 p. 65 R₁

f. 11v I

Verse 20 numbered 20 IM₃V₂ 1 लघुकेन्द्र] मृदुकेंद्र B₅, खलुकंड M₃, लघुखंड R₁V₂V₅, लघुकेन्द्र R₃, लघुखण्ड V₄ दोज्या] दोज्य R₃ 2 वेदा] विदा R₃, त्वेदा V₅ ४] om. B₅M₁M₂M₃R₁V₂V₅ सप्त] स V₄ ६७] om. B₅M₃R₁V₂V₅ 3 मेवं] मेव V₄ 4 मेतन्मृदु] मेतल्लघु R₁, भेतन्मृदु V₄ सञ्ज्ञकं] संज्ञितं R₂R₃V₅ **Verse 21** numbered 22 M₃ 5 त्रिज्याशु] त्रिज्या[x]शु R₂ कोटि] कोटि[म्] R₁ फलयो] फलयां V₄ 5-8 मृग—कर्णः] om. R₂, om. but म्मं erased in the line and the text added in margin मृदुकर्कटादौ केन्द्रे क्रमेण युतिरन्तरकं विधेयं ॥ तद्वर्गबाहुफलवर्गयुतेश्च मूलं कर्णः V₂ कर्कटादौ—कर्णः कुग om. R₃ 5 मृग] मृदु M₃, मृगा V₄ 6 केन्द्रे] केंद्र IR₁ क्रमेण] corrected from क्रमेणो to क्रमेण V₂ 7 बाहु] corrected from बाहू to बाहु I युतेश्च] युतेस्तु V₅ 8 कुगर्भ] कु[?]गर्भ R₂ सम्मितः] सम्मितः I, संमित M₁M₂V₄, सं[त]मितः M₃, संमित (:) ^{supl} R₂ **Verse 22** numbered 24 M₃, numbered 21 R₂ 9 आसन्न] marked and the gloss स्फुटमूलानयनम् added in margin by s R₂ मूलेन] om. B₅ हता] हता I वर्गा] गां M₃ 10 ल्लब्धेन] लब्धेन M₁ मूलं] मूले I सहितं] corrected from संहितं to सहितं V₅ द्वि] द्वि २ R₂R₃ 11 पदं] प B₅ 12 मुहुर्मुहुः] corrected from मुहुंमुहुः to मुहुर्मुहुः V₄ त्स्फुटमूलमेवम्] त्स्फुटमेवमेवं M₁, त्स्फुटमेवमेवं M₂, त्स्फुटमूलमेव M₃, दिति मूलमेवं R₁

त्रिज्यागुणं भुजफलं चलकर्णभक्तं
तल्लब्धकार्मुककलाः फलमत्र शीघ्रम् ।
एकेन सूर्यशशिनौ मृदुनाखिलेन
स्पष्टौ परे फलचतुष्टयसंस्कृताः स्युः ॥ २३ ॥

f. 13r V₄

मध्ये स्वचञ्चलफलस्य दलं धनर्णं

5 f. 10r B₅, f. 17v

V₅

कृत्वा ततो मृदुफलं दलितं च तत्र ।
तत्सम्भवेन मृदुना सकलेन मध्यो
मन्दस्फुटः स्फुटतरो ऽखिलचञ्चलेन ॥ २४ ॥

सम्यङ्मन्दफलस्फुटाच्चलफलं यत्साध्यते तत्स्फुटं
न ज्ञेयः प्रथमं मृदुस्फुटतरो मध्यग्रहात्केवलात् ।
तस्मादाशुफलार्धमन्दजफलाभ्यां संस्कृतान्मध्यमा-
ज्जातं मन्दफलं भवेत्स्फुटमलं किं चित्रमत्र क्रमे ॥ २५ ॥

10 f. 11v R₂

f. 46r V₂

f. 11r b V₃

Verse 23 numbered 25 M₃, numbered 22 R₂, numbered 33 but corrected to 23 V₄
1 त्रिज्यागुणं] त्रि गुं ज्या गुणं M₂, corrected from त्रिज्यागुणे to त्रिज्यागुणं R₃ भुज] निज V₄, (भुज)_{marg}
I, भु[f]ज V₂ 2 तल्लब्ध] तलब्ध M₂, लब्धस्य V₄ शीघ्रम्] शैघ्र्यं R₂, शैघ्रं R₃ 3 खिलेन]
खिले[x](न)_{marg,s} V₅ 4 फलचतुष्टय] फल[म] च[शीघ्रं ॥ एकेन सूर्यशिश x मृ⁷ xxxxx]तुष्टय with the च
corrected to this from त्र R₁, फलचतुष्टय V₄ स्युः] स्यु[r]: V₄ **Verse 24** numbered 25
M₃, numbered 23 R₂ 5 मध्ये] मध्य M₃, भधो V₄ स्व] ख M₃, स्प R₁ फलस्य] फलं स्व M₁M₂
धनर्ण] धनर्ण M₁, धनर्थ M₂ 7 सकलेन] सकले(न)_{supl} B₅ 8 मन्द] मंदः M₁R₃, मंद(:)_{supl} R₂
स्फुटः] स्फुट[r]: V₅ ऽखिलचञ्चलेन] खिलं च चलेन M₃ **Verse 25** omitted I, numbered 26
V₄ 9 सम्यङ्मन्द] सम्य marked and the annotation अत्रोपपत्तिः added in margin by s R₂, सम्यङ्मन्
R₃, corrected from सम्यक्मन्द to सम्यक्मन्द V₅ यत्साध्यते तत्स्फुटं] सत्साध्यते स स्फुटं V₅ 10 न ज्ञेयः]
न ज्ञेयः M₁, ज्ञेय M₃, ज्ञेयं R₁, ज्ञेयः⁻ V₄ स्फुटतरो] स्फुटतरो V₄ 11 फलार्ध] फ[xx](ला)_{marg,s} R₂,
फटनाद्ध R₃ फलाभ्यां] फलार्धा B₅M₁M₂V₃, फलाभ्या M₃ 12 ज्जातं] जातं V₅ फलं] दलं M₃
भवेत्स्फुटमलं] भवे स्फुटमलं M₁V₅, भवेत्स्फुट(ऽ)_{supl}मलं R₂ किं] कि R₁ चित्रमत्र क्रमे] चित्रम क्र^२त्र^१म्
V₅

मन्दकेन्द्रगतिरत्र दोगुण -
ज्यान्तरेण गुणिताद्यखण्डहृत् ।
संस्फुटैः प॥रिधिभिः समाहता
भांशहन्मृदुगतेः फलं भवेत् ॥ २६ ॥

नक्रकर्किमुखकेन्द्रतः फले -
नोनयुङ्गिजगतिर्मृदुस्फुटा ।
तां विशोध्य चल तुङ्गभुक्तिः
शेषमत्र चलकेन्द्रजा गतिः ॥ २७ ॥

साहताशुफलकार्मुकागमे
ज्यान्तरेण विहृताद्यजीवया ।
|कर्णहृत्तिभगुणाहता च्युता
शीघ्रतुङ्गगतितो गतिः स्फुटा ॥ २८ ॥

5

10

f. 13v V₄

Verse 26 numbered 25 I, numbered 27 M₃V₄ 1 मन्द] मांद M₁M₂ केन्द्र] के B₅,
केद्र V₅ रत्र] om. V₄ दोगुण] दोगुणा IR₁, (दो)_{marg,s}गुण R₂ 2 गुणिताद्य] गुणिताद्य with द्य
marked and द्य written in margin to make the reading clearer R₂, गुणिताय R₃, (गुणि)_{marg}ताद्य
V₃ खण्डहृत्] खंड २२५ हृत् V₂V₄, खंडहृत् V₅ 3 संस्फुटैः परिधिभिः समाहता] संस्फुटस्वपरिणाहसंगुणा
I, सा स्फुटस्वपरिणाहसंगुणा V₂V₄ संस्फुटैः] संस्कृतैः R₂R₃ समाहता] समाहिता M₂ 4 भांश]
भांश ३६० IM₁M₂V₂V₄, भांश R₂R₃, भांश V₅ हन्मृदुगतेः] in the main text between हन्मृदु and
गतेः is written between marks inserted later स्फुटा तां विशोध्य चलतुंगभुक्तिः शेषमत्र चल belonging to
the next verse (where an insertion mark is found at the appropriate place) but incorrectly
written here V₅ **Verse 27** numbered 26 IV₂, numbered 28 M₃ 5 नक्रकर्कि]
कर्किनक्र I, [xx]नक्र(कर्कि)_{marg} V₂, first कर्कि corrected to this from नक्र then न[?][x](क्र)_{marg} V₃,
के कि ने के V₅ केन्द्र] केन्द्र [द्र] I 6 नोन] corrected from नौन to नोन V₃ युङ्गिज] युङ्निज
M₃ मृदु] after मृदु is an insertion mark indicating that the text incorrectly written in
pāda d of the previous verse is to be inserted here V₅ स्फुटा] स्फुटा V₄ 7 तुङ्ग] केद्र M₃
भुक्तिः] भक्तिः M₂, भुक्तिः R₃ 8 केन्द्रजा] केन्द्रज M₂ **Verse 28** numbered 27 IV₂
9 हताशु] हताभ[?] V₃ गमे] गम R₂V₂V₄ 10 विहृताद्य] विहृताद्य I 11 हृत्तिभगुणाहता] हृत्ति (भ)_{marg}
I, हृत्तिभगुणाहता M₃, हृत्तिभगुणाहता V₄, ह (त्तिभगुणाह)_{marg,s}ता V₅ च्युता] न्युता R₃, (ऽ)_{supl}युता R₂
12 शीघ्र] शीघ्र [x] I, शी [घ्र]घ्र V₃ तुङ्ग] केद्र M₁M₂ गतिः] गति B₅ स्फुटा] स्फुटा: R₁

न शुद्धेद्यदा सा विलोमं विशोध्या -
वशेषं विलोमा गतिः खेचराणाम् ।
महद्गी रवीन्द्रोर्न शीघ्रोच्चनीचे
तथा वक्रता नेति पूर्वैर्निरुक्तम् ॥ २९ ॥

अतिदूरगतः स्वशीघ्रतुङ्गा -
त्कुरुते वक्रगतिं ग्रहस्तदानीम् ।
चलकेन्द्रलवा इमे ऽब्धिभूपाः १६४
कृतशक्राः १४४ खगुणेन्दव १३० स्त्रिभूपाः १६३ ॥ ३० ॥

शररुद्र ११५ मिताः कुजादितस्तै
रहिताः खङ्गगुणाः ३६० स्वमार्गभागाः ।
गदिताधिकहीनभागलिप्ता
विहृताः केन्द्रजवैर्गतागताहाः ॥ ३१ ॥

5

10 f. 5v M₂

Verse 29 numbered 28 IV₂, numbered 30 M₃ 1 शुद्धे] शुद्धे M₁R₁V₅, शुद्धे M₂, शुद्धे V₃
विशोध्या] विशोद्धा R₁ 2 वशेषं] ऽवशेषं M₃V₃, (5) ^{supl}वशेषं R₂ विलोमा] विलोमा M₂, corrected
from विलोमां to विलोमा M₃ गतिः] गतिः [स्फुटा ॥ २७ ॥] I खेचराणाम्] corrected from खेचराणां
to खेचराणां V₄ 3 महद्गी] महद्गी V₄ रवीन्द्रो] र[x]वीन्द्रो V₂ शीघ्रो] corrected from शीघ्रे
to शीघ्रो R₂, शीघ्रे R₃ between verse 29 and verse 30 is inserted अथ वा मृदुचंचलं फलं तल्लिखितं
सिद्धमितेषु कोष्ठकेषु ॥ मृदुचंचलकेंद्रदोर्विभागैः (:) ^{supl} करणीयं सुगमं ज्यका (व) ^{marg}ल्ल (numbered 29) I, अथ वा
मृदुचंचलं फलं लिखितं सिद्धमितेषु कोष्ठकेषु ॥ मृदुचंचलकेंद्रदोर्विभागैः करणीयं सुगमं ज्यकावदत्र (numbered 29) V₂,
अथ वा मृदुचंचलं फलं सिद्धमितेषु कोष्ठकेषु ॥ मृदुचंचलकेंद्रदोर्विभागैः करणीयं सुगमं ज्यकावदत्रा (numbered 30) V₄
Verse 30 numbered 31 M₃V₄, not numbered V₂, numbered 10 V₃ 5 दूर] दीर्घ
R₁, दूर V₄ गतः] गतिः M₂R₁, गत V₃, गत (:) [r] V₅ स्व] स्व? M₃ शीघ्र] शिघ्र V₄
6 गतिं ग्रह] गतिग्रह M₃, गतिर्ग्रह R₁, गति (:) ^{supl} ग्रह R₂ 7 लवा] भवा M₁M₂V₃ ऽब्धि] [द] ब्धि I
पाः] पा R₁V₅ १६४] om. R₂R₃ 8 कृत] [x] कृत I शक्राः] शक्रा R₁ १४४] om. R₁R₂R₃
गुणेन्दव] गुणैः दव R₁ १३०] om. M₃R₁R₂R₃, ३० V₄ भूपाः] भूपा (:) ^{supl} R₂ १६३] ६३
M₃, om. R₁R₂R₃ **Verse 31** numbered 32 IM₃V₂V₄ 9 शर] श (शि) ^{marg,s} R₂
११५] मिताः ११५ B₅IM₁M₂V₃V₄V₅, om. R₁R₂R₃ मिताः] मिता (:) ^{supl} R₂ स्तै] स्ते M₃
10 रहिताः] रहिता R₁, रहिता (:) ^{supl} R₂ खङ्ग] खांक I, खां M₃, खां (ग) ^{marg,s} R₂ गुणाः] गुणा I,
गुणः V₄ ३६०] ३६ B₅, om. R₁R₂R₃V₂V₄ भागाः] (भा) ^{marg,s} गाः V₅ 11 गदिता] उदिता R₂R₃
धिक] धीक M₁, दिक M₃ 12 विहृताः] विहृता IM₁M₂R₁ गता] गत् (r) R₂ गताहाः] गहताहाः
B₅

सौरं बाहुफलं हतं स्वगतिभिः । सर्वर्क्षलिप्तोद्धृतं

p. 67 R₁ & f. 12r R₂,

f. 11v V₃, f. 10v B₅

स्वर्णं दोःफलवद्गृहे स्फुटरवेरभ्युद्गमे स्यादतः ।

संयुक्तायनभागभास्करभवा जीवा जिनज्याहता

f. 9v R₃, f. 14r V₄

त्रिज्याप्तापमसिञ्जिनी धनुरतः क्रान्तिर्भवेद्गोलदिक् ॥ ३२ ॥

। सचलनदिनमालिदोर्गुणो य -

5 f. 47r V₂

स्तुहिनकराङ्ग ६१ विभागयुग्दशा १० सः ।

अनुपमगुणमेव तं युग ४ घ्रा -

मपमगुणं परिभावयन्ति सन्तः ॥ ३३ ॥

Verse 32 numbered 33 IM₃V₂V₄ 1 बाहु] भाव M₃, marked and the annotation भुजांतरम् written in margin by s R₂ हतं] हते R₃ गतिभिः] गतिभि R₁ लिप्तोद्धृतं] लिप्तो २१६०० दूतं B₅R₂R₃V₂V₃V₄, लिप्तो २१६० दूतं I, लिप्तोद्धृतं २१६०० M₁, लिप्तोद्धृतं M₂, लिप्तो २१६०० हृतं M₃, लिप्तादृतं R₁, लिप्तोद्धृतं २१६०० V₅ 2 स्वर्णं] स्वर्णं M₁, स्वर्णं R₁, स्वर्ण V₄, corrected from स्वर्णं to स्वर्ण V₅ दोः] दो (:) ^{supl} R₂ द्वे] द्वे M₁, तृहे M₂, द्व [r] हे V₄ स्फुट] स्फु [त] ट B₅ स्यादतः] स्यादत (:) ^{supl} R₂, स्यादत R₃, स्या (द) ^{marg} तः V₃ 3 संयुक्ता] marked and the annotation क्रान्तिसाधनम् written in the margin by s R₂ यन] यम M₃ भास्करभवा] भास्करभवा ११ M₁, भास्करभवा १२ M₂, भास्करभवा R₁, corrected from भास्करभवा to भास्करभवा V₄ जिनज्याहता] जिनज्या १३२७ हता B₅, जिनज्या १३९७ हता IM₃V₄, जिनज्या १३८७ हता with the ३ corrected to this from द M₁, जिनज्या १३८७ हता M₂, जिनज्याहता १३९७ V₂, जि [r] नज्या १३९७ हता V₃, जिन [r] २४ ज्याहता १३९७ V₅ 4 त्रिज्याप्तापम] त्रिज्या ३४३८ सा (प) ^{supl} म B₅, त्रिज्याप्तापम M₁, त्रिज्या ३४३८ सापम M₃, त्रिज्या ३४३८ सापम V₃, त्रिज्या ३४३८ सापम V₄V₅ सिञ्जिनी] सिञ्जि [f] नी I, सिञ्जनी M₁M₂R₁, सिञ्जिनी M₃, शिञ्जिनी V₃ क्रान्ति] क्रीति V₄ गोलदिक्] गोल [x] (दिक्) ^{marg,s} V₅ **Verse 33** numbered 34 IM₃V₂V₄ 5 चलन] चलन B₅, च [f] लन M₃, चलन R₁, (च) ^{marg,s} लन V₅ 6 स्तुहिन] स्तिमिर B₅IM₃R₁R₂R₃V₂V₃V₄V₅ कराङ्ग] काराग V₃ ६१] om. M₁M₂R₁ युग्दशातः] युग्दिगातः IV₄, युद्दिगातः V₂, युक्दिगातः V₅ १०] om. IR₁V₂V₄V₅ सः] मः M₂ 7 मेव] मेवं V₄ ४] om. R₁V₄, घ्रा ४ V₂ 7-8 घ्रमपम] घ्रं० मप M₂, घ्रापम V₅ 8 गुण] गुण R₁ परिभावयन्ति] परिभाभवयन्ति M₁, परिभाभुजावयन्ति M₂, परिभाचयन्ति V₅

क्रान्ति। ज्याकृतिवर्जितात्त्रिभवनज्यावर्गतो यत्पदं
 द्युज्या सा पलभागुणो ऽपमगुणः सूर्यै १२ हतः । कुज्यका ।
 द्युज्यासा त्रिभजीवया विगुणिता कुज्या चरज्या भवे -
 तच्चापं चरमुद्गमास्तमनयोस्तद्व्यक्षसाक्षान्तरम् ॥ ३४ ॥

f. 12r I

f. 18r V₅

खेटस्पष्टगतिर्हता चरपलैः षष्ठ्यु ६० द्यूता खेचरे
 स्वर्णं प्राप्तविलिप्तिका दिनमणेरस्तोदये गोलयोः ।
 नाड्यः पञ्चभुव १५ श्वरेण सहिता हीना उदग्गोलके
 गोलज्ञैर्द्युनिशादले निगदिते व्यस्ते तु ते । दक्षिणे ॥ ३५ ॥

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f. 47v V₂

Verse 34 numbered 35 IM₃V₂V₄ 1 क्रान्तिज्या] marked and the annotation पंचज्यासाधनम् added in margin by s R₂ तात्त्रि] ता त्रि IM₁M₂R₁V₄, त त्रि R₃ भवनज्या] भुवनज्या IM₂R₁, [भुवनज्या](भव[xx]नज्या) marg,s V₅ यत्पदं] यत्प[लं]दं with त्प corrected to this from त्फ M₁ 2 द्युज्या] द्युज्य M₂, द्युज्या R₃ सा पल] मा पल M₃, स्यात्पल R₂R₃ पलभागुणोपमगुणः] marked and the gloss क्रान्तिज्यापलभया गुणनीया added in margin V₂ ऽपम] पमा R₁ गुणः] गुणाः B₅R₁, गुण(:)supl I, गुण[r]: V₅ सूर्यैर्हतः] सूर्यैर्हतः B₅, सूर्योद्गतः IV₂V₄V₅, सूर्यै हतः M₃V₃, सूर्यैर्हतः R₁ १२] om. B₅IM₁M₂M₃R₁V₂V₃V₄V₅ 3 द्युज्यासा] द्युज्यांत्या I, ज्य द्यु सा M₂, द्युज्यासा M₃R₃ त्रिभ] त्रिभु M₃ विगुणिता] विगुणिता V₃V₅ चरज्या] चरज्या चरज्या V₄ 4 तच्चापं] तच्चाप M₃R₂R₃V₄ मनयो] मथयो M₃ स्तद्व्यक्षसाक्षान्तरम्] स्तद्व्यक्षसाक्षांतरं M₃, स्तद्व्यक्षांतरं V₄ **Verse 35** numbered 36 IV₂V₄, not numbered R₁ 5 खेटस्पष्ट] marked and the annotation चरसंस्कारः added in margin by s V₂, खेटस्प[x]ष्ट V₅ पलैः] पलै V₅ ६०] om. B₅R₁R₂V₃V₄V₅ द्यूता] धृता M₁V₅, द्यूताः V₂ खेचरे] खेचरै I, corrected from खेचरो to खेचरे R₃ 6 स्वर्ण] स्वर्ण B₅, स्वर्ण R₁ विलिप्तिका] विलि(f)प्त[r]क R₁ मणे] मृणे M₁, corrected from मर्णे to मणे V₄ स्तोदये] स्तोदयो M₁V₂, marked and the variant reading भ्युद्गमे recorded in margin by s V₅ 7 १५] om. B₅R₁R₂R₃V₂V₃V₅ 7-8 उदग्गोलके गोल] उदग्गोलमे गोल M₁, उदग्गोलगे गोल M₂V₃, उदग्गोलके गोल R₁, corrected from उदग्गेलयोगोल to उदग्गोलयोगोल R₂, उदग्गोलयोगोल R₃, corrected from उदग्गेलके गोल to उदग्गोलके गोल V₅ 8 निगदिते] निगदिते B₅, corrected from निगदितो to निगदिते V₅

खरकररहि।तामृताङ्गभागा

द्युमणिभि १२ रङ्ग ६ मितैः पृथग्विभक्ताः ।

।गततिथिकरणान्य।तो विशेषा-

न्निजहरतो ऽप्यनुपाततस्तु ना।द्यः ॥ ३६ ॥

f. 12r V₃

f. 12v R₂, f. 4v M₁

f. 14v V₄

करणमथ विरूप <१> मद्रि ७ शेष-

मसितचतुर्दशवासरोत्तरार्धात् ।

स्थिरशकुनिचतुष्पदाह्वनाग-

प्रभृतिचतुष्टयमेव योजनीयम् ॥ ३७ ॥

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इन्दोर्लवाः सरविचन्द्रलवास्त्रि ३ निघ्ना

भक्ताः पृथक्च खयुगै ४० र्गत।भानि योगाः ।

शेषं त्यजेन्नख २० हतं खखनाग ८०० तस्त-

त्षध्या हतं स्वगतिहृद्वटिकास्तदीयाः ॥ ३८ ॥

10 f. 13r I

Verse 36 numbered 37 IV₂V₄ 1 कर] कार V₄ मृताङ्ग] मृताग R₁, मृताङ्क R₂R₃, मृगाङ्क V₅
2 मणि] मुणि V₃ १२] मितैः १२। ६ B₅, मि १२ M₂V₂V₄V₅, om. R₁, मितै १६। ६ V₃ रङ्ग] रङ्ग V₄
६] मितैः १२। ६ B₅, om. IR₁V₄, मितै १६। ६ V₃ मितैः] मितै R₂V₃, दतैः V₄ भक्ताः] om. B₅
3 करणान्यतो] करणाद्यतो M₁M₂, करणान्यथो R₂R₃ विशेषा] पिशेषा V₅ 4 हरतो] गृहतो B₅, हरतो R₃
ऽप्यनु] ह्यनु M₁, ह्यनु M₂R₁R₂R₃V₃V₅ तस्तु] तोस्तु R₁ **Verse 37** numbered 38
IV₂V₄, numbered 27 R₁ 5 करणमथ] करणरपि R₁ विरूप] (वि)_{marg,s} V₅ मद्रि] माद्रि
V₄ ७] om. B₅IM₁M₂R₁V₂V₃V₄V₅ 6 मसित] म[xx]सित I, मसि[न]त V₃ चतुर्दश]
चतुर्द(f)श B₅, चर्दश I, चचतुर्दश M₂, चतुर्द(श)_{marg} V₃ 7 ह्] ख्य M₁M₂, ह्[?] V₃, [x](ह्)_{marg,s} V₅
8 चतुष्टयमेव] चतुष्टमेव M₁, चतुष्ट मे^३ ये^३ व M₂, चलष्टमे[x]व V₃ योजनीयम्] याजनीयं R₁ **Verse 38**
numbered 39 IV₂, numbered 391 V₄ 9 ३] om. B₅IM₁M₂R₁V₂V₃V₄V₅ 10 भक्ताः] भक्ता
B₅R₁, भक्ता(:)_{subl} I, भक्ता(:)_{subl} V₅ खयुगै] खगुणै R₂R₃, corrected from खयुगौ to खयुगै V₃
४०] om. B₅IM₁M₂R₁V₂V₃, ३० R₂, ३ R₃ योगाः] योगः V₄, यो[x]गाः V₅ 11 शेषं—नाग] शे^३ षं
त्य जेन्न^३ खह^३तं खख^३नाग V₃ शेषं] शेष R₃ 11–12 नख—स्तदीयाः] om. but written in main text
between marks in the next verse (see there) V₅ 11 २०] B₅V₃ हतं] हतं V₃V₅ ८००]
नागत ८०० B₅R₂R₃, om. R₁, नागत ८००० V₄ तस्तु] तष्टं V₂ 12 त्षध्या] त्षध्या ६० R₂V₄, षध्या V₂
हतं] हता M₂, हत V₃ स्वगति] खगति R₂ हृद्वटिकास्तदीयाः] हृद्वटिकास्तदीया(:)_{supl} V₃

नैकत्रोदयतः कुजे गृहविरामारम्भदेशौ कुत -

f. 11r B₅

स्तिर्यक्कादुडुमण्डलस्य न समास्तस्मादिमे भोदयाः ।

f. 48 V₂

एक १ द्वि २ त्रि ३ भ सिञ्जिनीकृतिनिजक्रान्तिज्यकावर्गतो
विश्लेषोत्थपदानि भत्रयगुणक्षुण्णानि तान्याहरेत् ॥ ३९ ॥

f. 10r R₃

स्वस्वद्युज्यकयाप्तचापमितयः स्वाधो विशुद्धाः क्रमा -

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देवं राश्युदयाः क्रमोत्क्रमगताः प्राप्ता निरक्षे पुरे ।

p. 69 R₁

एक १ द्वि २ त्रि ३ गृहोद्भवैश्वरदलैरूनाधिकाः स्युः क्रमा -

द्व्यस्तस्थैरुदयाः स्वकीयविषये षण्णां विलोमा धटात् ॥ ४० ॥

f. 15r V₄

Verse 39 numbered 40 IV₂V₄ 1 नैकत्रो—कुजे] om. written in main text between marks after *pāda* b (see there) V₅ नैकत्रो] नैकोत्रो M₁M₂, नेत्रोको V₄ गृह] गृह B₅, ग्रह M₁M₂V₅ रम्भ] रं(भ) marg,s V₅ देशौ] देशो M₁ 2 स्तिर्यक्का] स्तिर्यक्का? R₁ समास्तस्मा] समास्तस्मा I, समास्तस्मा M₁ भोदयाः] after भोदयाः is the last part of the previous verse and the beginning of the current verse inserted between marks in the main text ^{२०}नेखहतं ^{५००}खखनागतस्तु षष्ठ्या हतं [I] स्वगतिहृत्घटिकास्तदीयाः ३८ नैकत्रोदयतः कुजे V₅ 3 एक १ द्वि २ त्रि ३ भ] numerals om. B₅M₁M₂R₁V₃, एकद्वित्रि १।२।३ भ R₂, एकं द्वित्रि १।२।३ भ R₃, एकं द्वि त्रिभ V₅ सिञ्जिनीकृति] सिञ्जिनीकृत B₅, सिञ्जिनीकृति I, सिञ्जिनीकृत M₁, सिञ्जिनीकृत M₂, सिञ्जिनीकृत R₁, सिञ्जिनीकृत R₂R₃, सिञ्जिनीकृत (त) marg V₃ वर्गतो] वर्गको M₁M₂ 4 विश्लेषोत्थ] विश्लेषो ह्य? B₅, विश्लेषो स्य V₂V₄V₅ भत्रय] भवय R₂R₃, भ[त्रिभ]त्रय V₂ गुण] गुण ३४३८ B₅IM₁M₂V₂V₃V₄, गुण[R] ३४३८ V₅ क्षुण्णानि] क्षुण्णानि M₂, क्षुण्णानि R₁, क्षुण्णानि V₃, corrected from क्षुण्णोनि to क्षुण्णानि V₅ तान्याहरेत्] त(R)न्याहरेत् I **Verse 40** numbered 41 IV₂V₄ 5 द्यु] added in margin by s V₅ मितयः] मितदः? B₅ स्वाधो] स्त्वाधो I, स्वाधो M₁M₂ क्रमा] corrected from क्रमो to क्रमा B₅ 6 देवं] दे M₁M₂ क्रमो] क्रमा M₂, क्र(मो) marg,s R₂ गताः] गता V₃ निरक्षे] corrected from निरेक्षे to निरक्षे V₃ 7 एक १ द्वि २ त्रि ३] numerals om. B₅IM₁M₂R₁V₂V₃V₄, एकद्वित्रि M₁M₂, एकद्वित्रि १।२।३ R₂R₃, एक द्वि त्रि V₅ गृहोद्भवै] भवोद्भवै M₁, ग्रहोद्भवै M₂ रूनाधिकाः स्युः] om. V₄ क्रमा] क्रम[R] V₅ 8 द्व्यस्तस्थे] द्व्य स्तस्थे B₅, व्यस्तस्थे I, त्व्यत्यस्तस्थे R₁, द्व्यत्यस्थे R₂R₃, corrected from देव्यस्तस्थे to द्व्यस्तस्थे V₂, व्यस्तस्थे V₅ रुदयाः] रुदया IM₂ विषये] विशये R₁ षण्णां] षस्यां M₁, षष्ठ्यां M₂, षणां R₁V₃ विलोमा] विभोमा V₃ धटात्] धत् टा M₂, धरात् R₂, धयत् V₄, द्धटात् V₅

पादोनार्कलवा ११ । ४५ पमान्तरतयैवात्यन्ततिर्यक्स्थिता-
वाद्यं तौ क्रियमीनयोरुदयतः । स्वल्पैः स्वकीयैः पलैः ।
तौ नन्दा ९ पमभागकान्तरतया गोकुम्भयोरुद्धतौ
वेदा ४ पक्रमभागकान्तरगतौ युग्मैणयोर्विस्तृतैः ॥ ४१ ॥

f. 13r R₂

। राश्यन्तत्रयमौर्विका भवलये कर्णा निजोन्मण्डल-
क्रान्तिज्यास्तु भुजा दुरात्रवलये तत्कोटिचापोदयाः ।
भास्वद्भोदयभोग्यपूर्वभपलन्यूनेष्टना । डीपल -
व्योमाग्न्या ३० बिहतेरशुद्धभपलैराप्तं लवाद्यं तनुः ॥ ४२ ॥

5 f. 48v V₂

f. 13v I

Verse 41 numbered 42 IV₂V₄ 1 पादोनार्क] पादीनार्क I, पादीनार्का M₂, पादोनाक R₁,
पादो(ना)_{marg,s}र्क R₂, पादोर्क R₃, corrected from पादोनार्क to पादोनार्क V₃V₅, पादोनाद्य V₄ ११ ।
४५] पमांत ११ B₅, om. M₁M₂R₁R₂R₃, पमां ११ तर V₃, added in margin by s V₅ वात्यन्त]
वात्यन्त R₁, वात्यन्त R₂R₃ तिर्य] corrected from तिर्यु to तिर्य V₅ 2 वाद्यं] corrected from
वाद्यै to वाद्यं R₂, corrected from वाद्यं to वाद्यं V₄ मीन] मिन V₃ 3 नन्दा] मंदा R₁R₂R₃
९] om. B₅IM₁M₂R₁R₂R₃V₂V₃V₄, नंदा with numeral added by s V₅ 3-4 पमभागका—विस्तृतैः]
om. but added in main text between marks in *pāda* a of verse 43 (see there) M₂ 3 रुद्धतौ]
रुद्ध [x]तौ V₅ 4 वेदा] वेदो R₁ ४] om. B₅M₁R₁R₂R₃V₃V₅, वेदा I, वेदा V₂ पक्रम]
(प)_{supl}क्रम V₅ युग्मैणयो] युग्मैणयो R₁, corrected from युग्मैणयो to युग्मैणयो V₅ विस्तृतैः] विस्तृतिः
IM₁, विस्तृतैः R₁, विस्तृतौ R₂R₃, विस्तृतैः V₂, corrected from विस्तृतै to विस्तृतै V₄ **Verse 42**
pādas ab om. and *pādas* cd numbered with *pādas* ab of verse 43 as 44 I, not numbered V₂,
numbered with *pādas* ab of verse 43 as 43 V₄ 5-6 राश्यन्त—चापोदयः] om. I 5 राश्यन्त]
om. but added in main text between marks in *pāda* a of verse 43 (see there) M₂ त्रय] त्र V₅
भवलये] त्रवलये V₄ कर्णा] कर्णो R₁V₂V₄ निजोन्मण्डल] निजो मंडल M₁, निजोन्मंडला M₂, निज्योन्मंडल
V₃, निजोन्मंडले V₅ 6 ज्यास्तु] ज्या तु V₂V₄ भुजा] भु [ज्या] (जाः)_{marg} V₂ रात्र] रात्रि V₂V₄
वलये] वलये V₃ तत्कोटि] [वत्वो] (तत्को)_{marg} टि V₃ चापोदयाः] चापोदया (ः)_{supl} R₂, चापोदया R₃,
चापोदयः V₂V₄ 7 भास्व] भास्व [r] V₂ भोग्य] चोग्य M₂ पूर्वभ] between पूर्व and भ is enclosed
in brackets राशित्रयस्य जीवा १७१२ । २९७७ । ३४३८ क्रान्तिज्याः ६९८ । १२०९ । १३७७ B₅, पूर्वभ V₅ भपल] भपलं
R₂R₃, भपल V₂, corrected from भकल to भपल V₄ नाडीपल] नाडीफल M₁M₂ 8 व्योमाग्न्या]
व्योम (r)ग्न्या I ३०] om. R₁V₃V₄, ग्न्याभि ३० V₅ बिहते] बिहिते B₅V₄, बिहतै M₁M₂R₂R₃V₅
पलै] फलै V₄ राप्तं लवाद्यं] राप्तं चलाद्यं I, राप्तं लवाद्यं R₁, corrected from राप्ते लवाद्यं to राप्त लवाद्यं V₃,
रा (प्तं लवा)_{marg,s}द्यं V₅

मेषाद्यैरविशुद्धपूर्वभवनैर्युक्स्वाय।नांशोनितं

f. 6r M₂

लग्नं सायनसूर्यलग्नविवरे कालः पलादिर्भवेत् ।

रात्रौ षड्भयुतार्कतस्तु समयो लग्नं तु कार्यं यदा

f. 18v V₅

तावेकक्षगतौ तदन्तरलवैर्निघ्नोदयः खाग्नि ३० हत् ॥ ४३ ॥

p. 70 R₁

विषुवद्वलयाच्चलत्यजादिः

5 f. 49r V₂

स्खलिते ऽस्मिन्प्रवहानिले पुरस्तात् ।

f. 11v B₅

अतिचारिणि चापरत्र याति

प्रतिवर्षं न समास्ततो ऽयनांशाः ॥ ४४ ॥

Verse 43 *pādas* ab numbered with *pādas* cd of verse 42 as 43 and *pādas* cd numbered with half-verse inserted after this verse (see apparatus there) I, not numbered V₂, *pādas* ab numbered with verse 42 as 43 and *pādas* cd numbered with half-verse inserted after this verse (see apparatus there) V₄, numbering reorganized by s so that *pādas* ab are numbered with *pādas* cd of verse 42 as 42 and *pādas* cd numbered with half-verse added in margin by s (see apparatus after this verse) V₅ 1 मेषाद्यै] मेषाद्य R₁, पेषाद्य R₃ पूर्व] भूव Vth भवनै] between भ and वनै is inserted in main text between marks पमभागकांतरलया गोकुंभतोरुद्धतौ वेदापक्रमभागकांतरगतौ युग्मैणयोर्विसृतैः ॥ ४१ ॥ राश्यंत M₂ युक्स्वाय] युक्ज्ञाय M₁, युक्साय M₂, युक्साय R₁ 2-3 सायन—लग्नं] om. B₅ 2 कालः] काल R₁, कोलाः V₄ पलादिर्भवेत्] पलादि भवेत् M₁R₁, corrected from पलादि भवेत् to पलादिर्भवेत् R₂ 3 षड्भ] ष x (डभ)_{marg,s} V₅ समयो लग्नं] समयो लग्नं M₁, समयालग्नं with याग्न marked and variant reading यो ल added in margin by s V₅ तु] च IR₁V₂V₅, तु [तु] V₃ यदा] वदा R₁, सदा V₃ 4 तावेकक्ष] तावेक[x]क्ष I, तावेकक्षा R₁ गतौ] गतो M₁ तदन्तर] corrected from तदंतरं to तदंतर V₃ निघ्नोदयः] निघ्नोदयः M₁ ३०] om. B₅IR₁V₂V₃V₅, खाग्नि^{३०} M₂, ३ R₂R₃ हत्] हता R₂R₃ after verse 43 is कालः स्यादथ तत्समुत्थतरणे (:)_{supl} कालः स्फुटः स्यात्तत्स्तत्कालोद्भवभास्वतः पुनरयं संसाधितः प्रस्फुटः numbered with *pādas* cd of verse 43 as 43 I, कालः स्यादथ तत्समुत्थतरणेः कालः स्फुटः स्यात्तत्स्तत्कालोद्भवभास्वतः पुनरयं संसाधितः प्रस्फुटः numbered 44 V₂, कालः स्यादथ तत्समुत्थतरणेः कालः स्फुटः स्यात्तत्स्तत्कालोद्भवभास्वतः पुनरयं संसाधितः प्रस्फुटः numbered with *pādas* cd of verse 43 as 43 V₄, after verse 43 कालः स्यादथ तत्समुत्थतरणेः कालः स्फुटः स्यात्तत्स्तत्कालोद्भवभास्वतः पुनरयं संसाधितः प्रस्फुटः is inserted in margin by s V₅ **Verse 44** numbered 45 V₄V₂ 5 विषुव] विशव R₁, marked and the annotation अयनांशोपपत्तिः added in margin by s R₂ याच्च] या[x]च्च B₅, याब्ध M₁ दिः] दि B₅R₁R₂R₃V₂V₃V₅, दिक् M₂ 6 स्खलिते] स्खलिता R₁, corrected from स्खलितो to स्खलिते V₅ निले] निल V₄ पुरस्तात्] पुरस्ताः R₁, पुरस्तात् R₃ 7 अतिचारिणि] अ(प)_{marg}चारिणि B₅, अपपचारिणि M₁, अपचारिणि M₂R₁R₂R₃V₃V₅ याति] याति B₅M₁M₂V₃ 8 वर्ष] वर्ष R₁ समास्ततो] समस्ततो M₁M₂

मध्यप्रभार्ककरणागतसूर्ययोर्य -
 झागान्तरं भवति सायनभागसङ्ख्या ।
 वर्षान्तरेण कलिकान्तरमत्र दृष्टं
 प्रत्यक्षतस्तनुचरापमसाधनार्थम् ॥ ४५ ॥

f. 10v R₃

त्रिंशद्वटीपरिमितं दिनमीक्षणीयं
 तद्वासराकविषुवद्विनसूर्ययोर्यत् ।
 भागान्तरं भवति सायनभागसङ्ख्या
 तत्संस्कृतादपमलग्नचरादिसाध्यम् ॥ ४६ ॥

5

f. 13v R₂

f. 49v V₂

यत्सूक्ष्मभानयनमाद्यमुनिप्रणीतं
 तद्दृश्यभान्तरघटी विषमत्वतः स्यात् ।
 या वासना निगदितात्र पुरातनोक्ता
 त्रैराशिकादिसुगमापि न दोषदा स्यात् ॥ ४७ ॥

10 f. 14r I, f. 13r V₃

Verse 45 numbered 46 IV₄V₂ 1 सूर्ययोर्य] corrected from सूर्ययोर्ये to सूर्ययोर्य V₄
 2 झागान्तरं] झागंतरं R₁ भागसङ्ख्या] से ख्या भा ग M₁, चागसंख्या M₂ 3 कलिकान्तर] कलिकंतर V₄
Verse 46 numbered 48 IV₄, numbered 47 V₂ placed after verse 49 IV₂V₄
 5 त्रिंशद्वटी] त्रिंश ३० द्वटी R₂R₃, त्रिंशदघटी V₄ मीक्षणीयं] माकलय्य B₅R₂R₃V₃V₅, मानकलय्य M₁M₂,
 माकलैय्य R₁ 6 तद्वासरा] तद्वास(रा)_{marg} I, त[त]द्वासरा with an extra रा added in margin to
 make the reading clearer V₂ विषुव] विशुव I, विशव R₁ 7-8 भागा—साध्यम्] स्यादंतरं भवति
 ते यनभागका वा कालांतरेण गतिरत्र विलोकनीया I, same with स्यादं marked and variant reading भागां
 noted in margin by s V₂, same with ड्यन for यन V₄, marked and the variant स्यादंतरं भवति ते
 यनभागका वा कालांतरेण गतिरत्र विलोकनीया added in margin by s V₅ 7 भागान्तरं] शृगांतरं with शृ
 marked and the variant reading भा noted in margin V₃, corrected from भागांतरं to भागांतरं V₅
 भागसङ्ख्या] से ख्या भा ग M₁ **Verse 47** numbered 48 V₂ placed before verse 48 IV₂V₄
 9 यत्सूक्ष्म] यत्सूक्ष्मा B₅ मुनि] भुनि R₁ प्रणीतं] प्र[णी]णीतं B₅ 10 तद्दृश्य] तद्दृश्य R₁ विषमत्वतः
 स्यात्] विषमत्वतसत् B₅, corrected from विषमत्वतसत् to विषमत्वतस्तत् I, विषमत्व सत् M₁, विषमत्व सत्
 M₂, विशमत्वतः सत् R₁, विषमत्वतः सत् R₂R₃V₃V₅, विषुवत्वतः स्यात् V₄ 11 निगदिता] न गदिता B₅
 पुरात] पुरस्त V₅ 12 कादि] को?दि? marked and corrected to कादि in margin V₂ सुगमापि न]
 सुगमपि न B₅, सुगमा (त्र)_{marg} I, सुगमर न हि V₅

इत्थं श्रीमन्नागनाथात्मजेन
 प्रोक्ते तन्त्रे ज्ञानराजेन रम्ये ।
 ग्रन्थागाराधारभूते प्रभूते
 भुक्तेर्जाता स्पष्टता खेचराणाम् ॥ ५० ॥

Verse 48 not numbered B₅IR₃ 1 इत्थं] इति M₂, इत्थं with त्य marked and त्यं written in margin to make reading clear R₃ 1-3 नाथा—प्रभूते] om. B₅M₁M₂ 1 नाथा] marked and variant reading राज्ञा written in margin by s R₂ 2-3 प्रोक्ते—प्रभूते] om. V₃ 2 तन्त्रे] तंत्रं R₁ ज्ञानराजेन] ज्ञान[xxx]राजेन R₂ 4 भुक्तेर्जाता स्पष्टता खेचराणाम्] युक्त्यानीता स्पष्टखेटस्य (भु)_{marg}क्तिः I, खेचराणां स्पष्टभुक्तिर्निरुक्ता R₂, खेचराणां स्पष्टभुक्तिर्निरुक्ता R₃, गोलाध्याये स्पष्टखेटस्य भुक्तिः marked and variant reading भुक्तेर्जाता स्पष्टता खेचराणां added in margin V₂ जाता] याता M₁M₂ स्पष्टता] om. M₁M₂ **Colophon** इति श्रीनागनाथात्मजज्ञानराजविरचिते सिद्धांतसुंदरे स्पष्टाधिकारः संपूर्णः B₅, इति श्रीमत्सकलसिद्धांतरहस्ये वासनाविचारचतुरचित्तचमत्कारिण सिद्धांतसुंदरे स्फुटगतिसाधनं नामाध्यायः I, इति सिद्धांतसुंदरे स्पष्टीकरणाध्यायोद्वितीयः M₁, इति सिद्धांतसुंदरे स्पष्टीकरणाध्यायो द्वितीयः M₂, om. R₁R₃V₅, इति श्रीनागनाथात्मजज्ञानराजविरचिते सिद्धांतसुंदरे (गणिताध्याये)_{marg,s} स्पष्टाधिकारो द्वितीयः in margin by s R₂, इति सिद्धांतसुंदरे स्फुटगतिसाधनं नामाध्यायः V₂, इति श्रीनागनाथात्मजविरचिते सिद्धांतसुंदरे स्पष्टाधिकारः संपूर्णः V₃, इति श्रीमत्सकलसिद्धांतवासनाविचारचतुरचित्तचमत्कारिण सिद्धांतसुंदरे स्फुटगतिसाधनं नामाध्यायः (folio change to f. 16r) V₄

⟨अथ ग्रहगणिताध्याये त्रिप्रश्नाधिकारः⟩

।सद्वासनाकुसुमसञ्चयसुन्द।रस्य
चञ्चद्विशालतरगोलतरोः परस्य ।
दिग्देशकालकलनाफलसाधनार्थं
त्रिप्रश्नसञ्ज्ञमधिकारमथाभिधास्ये ॥ १ ॥

f. 15v g V₄, p. 71 R₁

5

।अंभःसमीकृतमहीतलसंस्थितस्य
च्छाया दिनार्धघटिकासु समस्य ^(a) शङ्कोः ।
याम्योत्तरा भवति सैव तदुत्थमत्स्य -
पुच्छास्यतस्त्वपरपूर्वदिशौ भवेताम् ॥ २ ॥ ^(b)

f. 12r B₅

उत्तुङ्गभागसमभूमिगवृत्तकेन्द्र -
कीले निवेश्य शिथिलां सरलां ।शला।काम् ।
प्रोद्यद्दिवाकरमुखीं परिधौ तदग्रा -
द्वस्ताग्रकाजनितचापलवैर्दिगैन्द्री ॥ ३ ॥

10

f. 50r V₂, f. 14v I

chapter opens श्रीलंबोदरो जयति I, श्रीगणेशो जयति V₂ Verse 1 2 सद्वासना] यद्वासना I, सद्वासन R₁
3 तरोः] तरो R₂R₃ 4 कलना] (कल) _{marg,s} ना R₂ फल] पल V₃ 5 रमथा] (र) _{marg,s} मथा R₂
भिधास्ये] तिदास्ये V₅ Verse 2 7 घटिकासु] घटिकाःसु V₅ शङ्कोः] शेकोः B₅ 8 सैव]
corrected from सौव to सैव V₃ 8-9 तदुत्थमत्स्यपुच्छास्यतस्त्वपरपूर्वदिशौ भवेताम्] ततस्तदुत्थमत्स्यास्यपुच्छत
इहेन्द्रजक्षाधिपाशे R₁, not marked but variant reading ततस्तदुत्थमत्स्यास्यपुच्छत इहेन्द्रजलाधिपाशे added in
margin R₃ 8 तदुत्थ] तदुत्प R₃ मत्स्य] om. but added in margin V₃ 9 पूर्व] पूर्वौ M₁
Verse 3 numbered 43 R₃ 10 उत्तुङ्ग] marked and the annotation प्रकारांतरम् added in
margin by s R₂, उत्तंग V₅ भूमिग] भूमिक B₅M₁M₂R₂R₃V₃ वृत्त] वत V₅ केन्द्र] केव्द V₄
11 शिथिलां सरलां] शिथिली रलां B₅, त्रिथिलां सरलां M₁, शरलां शिथिलां R₁, शिथिलां स(र) _{supl} लां V₃,
सरलां शिथिलां V₅ शलाकाम्] शलकां R₁ 12 प्रोद्य] corrected from प्रेद्य to प्रोद्य R₁, प्रोद्यु R₃
दिवा] दि[व]वा V₃, दिवा V₅ मुखीं] मुखी V₅ 12-13 तदग्राद्य] दे ते ग्राद्य B₅, तदग्रात्स्य R₂, तदग्राह्य?
R₃, तदग्रव्य V₅ 13 जनित] जनिता V₄ दिगैन्द्री] दिगेंद्री M₁R₁, corrected from दिगेंद्रि to दिगेंद्री
M₂

(a). The reading दिनार्धघटिका सुसमस्य is also possible.
2.1.26.

(b). This verse is identical to verse

स्याद्वारुणी कथितकेन्द्रगताथ केन्द्र -
कीलप्रभा रविवशेन विशत्यपैति ।
तत्रापरेन्द्रककुभौ भवतः क्रमेण
सौम्या ध्रुवे भवति चेति हरिद्विधानम् ॥ ४ ॥

f. 14r R₂

कन्यामीनान्तस्थिते सायनांशे
भानौ मध्याह्नप्रभाक्षप्रभेयम् ।
बाहुः कोटिर्नाक्षकर्णो ऽत्र कर्णः
क्षेत्रेष्वद्यं क्षेत्रमक्षोद्भवेषु ॥ ५ ॥

5 f. 16v V₄

f. 11r R₃

आभूम्यक्षालम्बसूत्रं पलज्या
बाहुः कर्णो भूमिगर्भाक्षमध्वे ।
त्रिज्या लम्बज्यात्र कोटिर्निरुक्ता
पृथ्वीगर्भादक्षजीवाग्रगेयम् ॥ ६ ॥

f. 13v V₃, f. 19r V₅

10 p. 72 R₁

Verse 4 numbered 40 R₁ 1 केन्द्र] केद्रा B₅ गताथ] गताथ B₅ केन्द्र] केद्र V₃V₅
2 कील] marked and the annotation नित्यप्राची added in the margin by s R₂, कील: V₅ प्रभा]
प्रभा x V₃ वशेन] कशेन V₄, वशे? z V₅ विशत्यपैति] विशत्युपैति M₁M₂, विशत्यपैति R₁, वि? z पैति V₅
3 तत्रापरेन्द्र] तत्रापरे? z V₅ ककुभौ] ककुलो M₂, कुकुभौ R₁, corrected from कुकुभौ to ककुभौ V₂ क्रमेण]
क्र[r]मेण V₄, क्रमे z V₅ 4 सौम्या] सौम्य V₂, सौम्ये V₅ ध्रुवे] ध्रुवे B₅, ध्रुवे R₁ चेति] वेति IV₄
हरिद्विधानम्] ह (रि)_{marg} द्विधानं I, marked but no annotation found in the margin R₂ **Verse 5**
not numbered V₄ verse hard to read due to highlighting by scribe V₅ 5 कन्या]
कन्या V₂ मीनान्तस्थिते] मीनांत: (f) स्थिते V₃, मीनांतव:स्थिते V₄ नांशे] नांशि B₅, नांशे R₃, नांशे? V₅
6 भानौ म] भानोर्म V₄ प्रभेयम्] प्र[र]भयं B₅, प्रभासौ R₁ 7-8 बाहुः—इवेषु] om. V₄ 7 बाहुः]
बाहु (:)_{supl} I कोटिर्ना] कोटिना B₅V₃ क्षकर्णो] क्षिकर्णो M₁M₂, क्षकर्णे V₅ ऽत्र कर्णः] त्रिकर्णः V₅
8 क्षेत्रेष्व] क्षेत्रे [x] ष्वा B₅, क्षेत्रष्व M₂ इवेषु] इवेषु B₅, इवेषु R₁, as in text with षु and the first
akṣara of verse 6 marked and the annotation अष्टावक्षक्षेत्राणि added in margin by s R₂, इवेषु R₃
Verse 6 9 आभूम्य—पलज्या] om. V₄ आभू] with the आ marked together with last akṣara
of previous verse (for annotation see there) R₂ म्यक्षालम्ब] म्यक्षां लंब M₁M₂, म्य[r]त्सालम्ब R₂,
म्यक्षालम्ब? च V₅ 10 कर्णो] कर्णा V₅ गर्भाक्ष] गर्भाक्ष R₁, [x]भाक्ष R₂, वार्भाक्ष R₃ मध्ये] मध्यो V₄
11 कोटिर्नि] कोटिनि R₁, कोटिनि? V₅ 12 दक्ष] द(ऽ)_{supl}क्ष R₂ ग्रगे] ग्रके(गे)_{marg} V₃

पूर्व ज्ञाता कुज्यका बाहुरूपा
क्रान्तिज्या स्यात्कोटिरग्रात्र कर्णः ।
एको बाहुः कुज्यकान्यो ऽपमज्या
भूरग्रा स्याल्लम्ब उद्धृत शङ्कुः ॥ ७ ॥

f. 50v V₂

f. 12v B₅

आद्याबाधाग्रादिखण्डं हि कोटिः
कर्णः क्रान्तिज्या तथोद्धृतना दोः ।
अन्याबाधा बाहुरुद्धृतशङ्कुः
कोटिः कर्णः कुज्यकैवेह जात्ये ॥ ८ ॥

5

सममण्डलसङ्गतादिनेशा -
दवलम्बः समवृत्तशङ्कुरुक्तः ।
अयमत्र हि कोटिरग्रका दोः
श्रवणस्तद्धृतिरेव जात्यमन्यत् ॥ ९ ॥

f. 15r I

10

Verse 7 1 पूर्व] पूर्व B₅, कुपूर्व V₄ ज्ञाता] ज्ञाना M₂ कुज्यका] after कुज्यका is written but erased न्यो पमज्या भूरग्रा स्याल्लम्ब उद्धृतशङ्कुः I, कुज्यकं V₅ 2 रग्रात्र] रग्रत्र R₁, रग्रा (त्र) marg M₂, रग्रा च V₄ 3 कुज्यका] कुज्यक R₁V₄ ऽपमज्या] x मज्या B₅, पमाज्या R₁, पज्या V₄, प²म²ज्या V₅ 4 ल्लम्ब] ल्लव R₁ उद्धृत] उद्धृत M₁R₁, उत्तृत M₂ **Verse 8** 5 बाधा] बा²धा V₅ ग्रादिखण्डं] ग्रा²खण्डं V₄ कोटिः] कोडिः V₄ 6 कर्णः] कर्ण V₂V₄ तथोद्धृत] तथोद्धृत I, तथावृत्ति M₁, तथाद्धृत M₂, तथोद्धृत R₁, तथोद्धृत R₂ 7 अन्या] अ[r]न्या M₁, अंत्या R₁V₂V₄ रुद्धृत] रुद्धृत IR₁, रुद्धृत M₁ शङ्कुः] corrected from शङ्को: to शङ्कुः B₅ 8 कोटिः] कोटि I कुज्यकैवेह जात्ये] कुज्यकैवेह ज्यात्ये V₅ **Verse 9** 9 सम] स M₁M₂ मण्डल] मंडलं V₅ तादिनेशा] ता दिनेशा V₅ 10 दवलम्बः] लवदंभः M₂, दलंभः V₄ वृत्] वृत् B₅ 11 अयमत्र] अयमत्रा M₂, अपमत्र R₁, अपरत्र R₂R₃, अ[r]यमत्र V₄ रग्रका] रग्नका M₂ दोः] दो M₁M₂V₄ 12 श्रवण] श्रवणा M₁ स्तद्धृति] स्तद्धृति I, स्तद्धृति M₁M₂, स्तद्धृति R₁, स्तद्धृति marked and the annotation अर्कविंबात्त्वोदयास्तसूत्रं तद्धृतिः added in margin V₂

उद्धृतशङ्कुरहितः । समनाथ कोटिः
 कुज्योनतद्धृतिमितः श्रवणस्तथात्र ।
 अग्रादिखण्डमिह दोरिति जात्यमन्य -
 त्वखण्डद्वयं समनुरस्ति हि तद्धृतेष्व ॥ १० ॥

f. 6v M₂

। अपमांशकसिञ्जिनी भुजो वा -

5 f. 51r V₂, f. 14v

R₂

वनिजीवो । निततद्धृतिस्तु कोटिः ।
 सममण्डलशङ्कुरत्र कर्णः
 समवृत्तोत्तरयाम्यगे ऽपि सूर्ये ॥ ११ ॥

f. 5r M₁

f. 15v I

एतेषु चान्यतमदोः श्रुतिको । टिमानै -
 स्त्रैराशिकेन परजात्य । भुजादिसाध्यम् ।
 दोः कोटिवर्गयुतिमूलमुत श्रुतिः स्या -
 तद्वाहुवर्ग । वियुतेः पदमत्र कोटिः ॥ १२ ॥

p. 73 R₁

10 f. 17r V₄

f. 14r V₃

Verse 10 1 उद्धृत] उद्धृत IM₁R₁ समनाथ] समना च R₂R₃ 2 तद्धृति] तद्धृति I, तद्धृति R₁V₅
 श्रवणस्तथा] corrected from श्रवणेस्तथा to श्रवणस्तथा I, श्रवणःस्तथा M₁ 3 मिह] मिह V₅
 दोरिति] दोरिति V₄ जात्य] जाज्य B₅, om. but added in margin V₃ 4 त्वखण्ड] खंड V₅
 समनु] समनु R₁, सम[R]नु R₂ हि] च B₅IV₂V₄ तद्धृते] तद्धृते V₅ 5 अ] अ V₄ **Verse 11**
 placed after verse 12 (which is numbered 11) and numbered 12 IV₂V₄, placed after verse 12
 (which is numbered 12) and numbered 11 M₁M₂ 5 अपमांशक] अपमांशक B₅, अपमांसक V₅
 सिञ्जिनी] सिञ्जिनी M₁M₂, सिञ्जिनी V₃, शिञ्जिनी V₄ भुजो] om. M₁, भुवो M₂ 5-6 वावनि] वाऽवनि
 IR₂R₃V₄, वावि V₅ 6 नित] (नि)_{marg}त V₂ तद्धृति] तद्धृति R₁, तद्धृत V₅ कोटिः] कोटि (:) _{supl}
 R₂ 7 सम] स V₄ शङ्कु] कु V₄ 8 वृत्तो] वृत्तो M₁ याम्यगे] याभ्यगे V₄ सूर्ये] सूर्येः V₅
Verse 12 placed before verse 11 (which is numbered 12) and numbered 11 IV₂V₄, placed
 before verse 11 (which is numbered 11) and numbered 12 M₁M₂ 9 एतेषु] एतेषु I, तैरेषु V₄
 चान्य] वान्य M₁, वान्य M₂ तम] सम B₅M₁M₂R₂R₃V₃ दोः] दो IM₂V₅ श्रुति] श्रुति B₅V₂
 मानै] मामै B₅, माने R₁ 10 स्त्रैराशिकेन] स्त्रैरा (f)शकेन I, त्रैराशिकेन R₁, स्त्रैराशिकेन V₃, स्त्रैराशिकेन V₅
 परजात्य] परिजात्य R₁ 11 दोः] दो (:) _{supl} IR₂, दो R₃ मूलमुत] मूलयुतः M₁, मूलमुतः M₂R₁V₂,
 मूलमित (:) _{supl} R₂, मूलयुत R₃, मूलमिति V₅ श्रुतिः] श्रुतिः B₅R₁V₃, श्रुति (:) _{supl} I 12 तद्वाहु] तद्वाहु
 V₃, तद्वाहु V₄ वर्ग] वर्ग V₃, वर्ग V₄ वियुतेः] वियुते M₂, (वि)_{marg}युतेः R₃ पद] पर V₃
 कोटिः] कोटि (:) _{supl} R₂

शङ्खवक्षभे कोटिभुजौ क्रमेण
चेदक्षकर्णश्रवणे तदानीम् ।
त्रिज्यामिते काविति लम्बजीवा -
पलज्यके स्तः किल कोटिबाहू ॥ १३ ॥

उत दिनदलभाश्रुतौ भुजो भा

5 f. 13r B₅, f. 11v

R₃

भवति तदा त्रिभमौर्विकाश्रुतौ किम् ।
फलमितनतभागमौर्विकास्याः
समुदितवत्पलभागकाः प्रसाध्याः ॥ १४ ॥

उन्नाग्रकाग्राप्रथमान्त्यखण्डै -
रक्षश्रुतिः सङ्गुणिताक्षभाप्ता ।
क्रान्तिज्यका स्यादथ तद्धृतिश्च
तदूर्ध्वखण्डं क्षितिमौर्विका च ॥ १५ ॥

10

Verse 13 numbered 12 M₂ 1 शङ्खवक्ष] शङ्खक्ष M₁, शङ्कुक्ष V₅ 2 कर्ण] कर्णर्या B₅, कर्णः M₁M₂ श्रवणे] श्रवणौ R₁, corrected from श्रवणे to श्रवणे V₄ 3 मिते] भुजे I, मिचेत्ति M₁M₂, श्रुतौ R₁, [भुजे](श्रुतौ)_{marg} V₂, श्रुतौ V₄V₅ काविति] कात्थिति M₂, काविति[तक्ष] R₃ 4 पल] फल V₅ ज्यके] corrected from ज्येके to ज्यके M₂ स्तः] स्तु R₁ बाहू] बाहुः B₅R₁, बाहु M₂V₅
Verse 14 5 उत] उत्त्व B₅, उ(त)_{marg} V₂ श्रुतौ] श्रुतौ B₅V₃, श्रुतौ M₁, श्रितौ R₁ भुजो] भुजा B₅V₃, भुजौ M₁R₁V₅, भुज्यो V₄ 6 भवति] भवेति M₁ श्रुतौ] श्रुतौ B₅V₃, श्रुतो M₂, श्रुतौ R₁ 7 मित] मिति R₁ नत] पल R₂ 8 समुदितव] समुदितत V₄ त्पल] त्फल M₂ भागकाः] भामकाः M₁
Verse 15 9 उन्ना] उक्ता V₅ ग्रकाग्राप्र] ग्र[r]कायात्प्र V₄, ग्रकाग्रात्प्र V₅ खण्डै] corrected from खंडा to खंडै after which is written but erased न्यकाहतान्यर्कभयोद्धृतानि V₃, corrected from खंडै to खंडै V₄ 10 रक्ष] रक्षः M₁M₂V₃ श्रुतिः] श्रुतिः B₅V₃, श्रुतिः R₁ सङ्गुणिता] संगुता M₂ भाप्ता] भक्ता R₁, भास्त्र V₄ 11 स्यादथ] स्या समुदिदथ V₅ तद्धृति] वा धृति B₅M₁M₂R₂V₃, तद्धृति R₁, वां धृति R₃, संधृति V₅ 12 तदूर्ध्व] तदूर्ध्व R₁, तदूर्ध्व V₄ खण्डं] after खण्डं is written but erased तथोद्धृतनरः क्रमात्स्युः B₅ क्षितिमौर्विका च] om. but added in margin B₅, क्षितिमौर्विकं च R₁

उन्नाग्रकाग्राप्रथमान्त्यखण्डा -

न्यर्का १२ | हातान्यक्षभयोद्धृतानि ।

f. 16r I

| अग्रादिखण्डं समना तदूर्ध्व -

f. 51v V₂

खण्डं तथोद्धृतनरः क्रमात्स्युः ॥ १६ ॥

| अथ देशविषयाः प्रश्नाः ।

5 f. 17v V₄

सिंहासनासीनमिनत्वमाप्तं

मित्रं विदित्वाद्युतिरुत्तराशाम् ।

यातो ऽभवत्पूर्वनृपप्रभो य -

| स्तस्याशुपुंसो वद यानमानम् ॥ १७ ॥

f. 15r R₂, p. 74 R₁

सूत्रम् ।

10

स्थानद्वयोद्धृतपलान्तरालं

मनु १४ घ्रमेवं गतियोजनानि ॥ १८ ॥

Verse 16 1 उन्ना] उक्ता V₅ काग्राप्र] काग्र R₁, काग्रात्प्र R₃V₄ 2 १२] om. B₅IM₁M₂R₁R₃V₂V₃V₄V₅, न्यर्का^{१२} R₂ हातान्यक्षभ] हतान्य^{१२}भ B₅, हतान्यर्कभ M₂R₃ योद्धृतानि] योद्धृताति M₁M₂, योद्धृतानि V₄ 3 अग्रादि] अग्राग्र R₁, आग्रादि V₄ समना त] समनात्त M₁M₂, समनां त R₁, स(म)_{marg,s}ना त R₂, सना त R₃ दूर्ध्व] दूर्द्धा I, दूर्द्ध R₁, दूर्ध्व R₂R₃, दूर्द्ध V₄ 4 तथोद्धृत] तथोद्धृत I, तथोद्धृत M₁, तथोद्धृत M₂, तथोद्धृत R₁, तद्धृत V₄, तथोद्धृतानिवृत्त V₅ क्रमात्स्युः] क्रमा स्युः M₁, क्रमात्स्या(त्)_{marg,s} R₂, क्रमेण V₄ 5 अथ—प्रश्नाः] om. R₁V₅ अथ देश] अथा द[r]शं V₄ विषयाः] विषया B₅M₁, या(:)_{supl} I, विषय[x] R₂ प्रश्नाः] प्रश्न(r): R₂, प्रश्ना R₃ **Verse 17** 6 सिंहा] सिं[१]हा I माप्तं] माप्तं V₅ 7 विदित्वाद्युति] विदित्वा(ऽ)_{supl}द्युति V₂V₃ राशाम्] राशाम् V₄ 8 यातो] पा^१तो V₃ ऽभव] भवे M₁, (ऽ)_{supl}भव V₂ त्पूर्व] त्पूर्ण V₅ नृप] नृप V₄ 9 स्तस्या] स्तस्ता V₅ यान] यानु V₅ **Verse 18** not numbered in any of the mss. om. R₁ 10 सूत्रम्] om. V₅ 11 इत] om. but added in margin R₂ 12 १४] om. B₅IM₁M₂R₁V₂V₃V₄V₅

अत्रार्कः सिंहार्धे ४।१५ आद्या छाया ० द्वितीया पूर्वछाया
१६ । अत्र क्रान्तिज्यानरयोर्द्विचन्द्र १२ हृतयोरित्यादिना
वक्ष्यमाणप्रकारेणाक्षभातो ऽक्षांशानानीय जातानि योजनानि १६७ ।

f. 14v V₃

अपि च ।

नक्रमुखे ऽस्तमिते सति हंसे

5

मानसतश्चलितो मुनिराजः ।

ईशदिशि द्युतिमीशसमानां

f. 16v I, f. 19v V₅

पश्यति तत्र । व। दाक्षजभां मे ॥ १९ ॥

अथ सूत्रम् ।

क्रान्तिज्यानरयोर्द्विचन्द्र १२ हृतयोर्वर्गान्तरं दृग्गुणं

10

हारः स्यान्नरष ६ इलवेन गुणितो बाहुर्भवेन्मध्यमः ।

क्रान्तिज्याभुजवर्गयोश्च विवरं नेत्र २ घ्राहाराहतं

यत्तन्मध्यमवर्गहीनयुगतो मूलं च मध्योनयुक् ॥ २० ॥

f. 18r V₄

1 अत्रार्कः] अत्रार्के I सिंहार्धे] corrected from सिंहो to सिंहा B₅ ४।१५] ४१५ V₄ आद्या] आद्य V₄
०] om. B₅M₁M₂, ७० R₂R₃ पूर्वछाया] पूर्ववच्छाया R₂R₃ 2 १६] om. B₅M₁M₂, छाया^{१६} V₃
नर] पर M₁M₂ द्वि] द्वि V₂ हृत] ते हे V₃ दिना] दिन (r) I 3 माण] माण [माण] V₃
प्रकारेणा] प्रकारेणा (ऽ)^{supl} R₂ क्षभातो] om. V₂V₄ १६७] १५७ B₅M₁M₂R₂R₃V₃ Verse 19
not numbered B₅V₃V₅, numbered 19 M₁M₂, numbered 18 R₂R₃V₂V₄ 4 अपि
च] उदाहरणं R₁, om. V₅ 5 मुखे] मुख V₄ ऽस्तमिते] स्तमि (ते)^{marg} V₃ हंसे] सिंहे R₁
7 ईश] ईशा M₁M₂, ईश V₄ मीशसमानां] मीश ११ समानं IR₂R₃, मीशसमानं M₁V₅, ईशसमाना R₁
8 क्षजभां] क्षज [r] भां B₅, corrected from क्षजं भां to क्षजभां M₁, क्ष [xxxxxxx] भा V₅ after verse 19
अव्यक्तवर्गाश्रितमूलभक्तमव्यक्तखंडं फलवर्गरूपैः । पक्षौ युतो नौ प्रविधाय मूले ततः समीकारविधेस्तु राशिः ॥ numbered
21 R₁ Verse 20 not numbered B₅V₃, numbered 18 IV₂V₅, numbered 18 R₁,
numbered 19 R₂R₃V₄ 9 अथ सूत्रम्] om. V₅ अथ] om. B₅R₁, अत्र I 10 क्रान्ति] का
x B₅ नरयो] नरयो V₅ १२] om. B₅IM₁M₂R₁V₂V₃V₄V₅ हृतयो] हृतयो [r] B₅, हृतयो V₄
वर्गान्तरं] वर्गांतरं V₅ दृग्गुणं] दृग्गु. न V₅ 11 हारः] corrected from हारं to हार M₁, हार I
स्यान्नर] स्वानर V₄, स्यान्नर V₅ इलवेन] इलवे B₅, इणवेन I, इलवेन R₃ बाहु] बाहु V₄ भवेन्मध्यमः]
भवेन्मध्यम [r] : M₁, corrected from नुंचे मध्यमं to नंचे मध्यमः V₄ 12 वर्गयोश्च] वर्गायोश्च R₂, वर्गयोस्तु V₅
घ्रा] [x] [घ्रा]^{marg,s} R₂ हतं] हतं R₁R₂R₃ 13 यत्तन्मध्यम] यत्तं मध्यम M₁, corrected from
यत्तन्मेध्यम to यत्तन्मध्यम R₃, corrected from यत्तन्मध्यमे to यत्तन्मध्यम V₄, यत्तन्मध्यम V₅ वर्ग] om. I
युगतो] युगतौ V₅

शङ्कौ क्रान्तिगुणाधिकाल्प इह यल्लब्धं हरेणाक्षभा
स्याद्दिग्ज्यागुणिता द्युतिः श्रवणहृद्वाहुर्भवेदिष्टदिक् ।
दिग्ज्या त्रिज्यकया यदा द्युतिमिते किं स्यात्प्रतीतौ भुजः
शोध्यं शुध्यति नो तदोत्क्रमतया शोध्यं स्वबुद्ध्याखिलम् ॥ २१ ॥

f. 13v B₅, f. 12r R₃

क्रान्तिज्यानरयोरित्यत्र वासनाश्लोकः ।
अव्यक्ताक्षभयानयेन्नरतलं तद्वाहुसंस्कारतः
स्यादग्रा रवि <१२> वर्गयुक्तपलभावर्गो ऽक्षकर्णे कृतिः ।
क्रान्तिज्याकृतिसङ्गुणार्क <१२> कृतिहत्साग्राकृतिस्तत्समा
पूर्वाग्राकृतिरत्र साम्यकरणाद्वीजक्रियातो ऽक्षभा ॥ २२ ॥

5 f. 15v R₁

f. 17r I, f. 52v V₂

न्यासः ।

10

सूर्यः ९ । ० । ० । ० लघुज्याप्रकारेणास्य क्रान्तिज्या ६४ । २० नरः
११७ । ४८ दिग्ज्या ११२ । ० लब्धाक्षभा १ । ७ अक्षांशाः ५ । ७

f. 7r M₂, f. 14v e V₃

Verse 21 not numbered B₅V₃, numbered 19 IR₁V₂V₅, numbered 20 R₂R₃V₄, not
numbered V₃ 1 शङ्कौ] शङ्को B₅, शङ्कौ V₄ क्रान्ति] क्रान्त V₅ गुणाधि] गुणाधि R₃, गुणरधी V₅
यल्लब्धं] यल्लब्धं I, लब्धं V₅ क्षभा] क्षणा B₅ 2 स्याद्दि] स्यादि V₅ ग्ज्या] ग्ज्या [त्रिज्यकया यदा
द्युतिमिते] V₃ द्युतिः] द्युति IV₄V₅, युति R₁ द्वाहुर्भं] वाहुर्भं M₂ 3 त्रिज्यकया] त्रिज्यकया M₂
यदा] यदि R₂R₃ 4 शोध्यं] शौध्यं V₅ शुध्यति] शुद्ध्यति I, शुद्ध्यति R₂V₄ तदो] दतो B₅, दो
V₃ स्वबुद्ध्या] सुबुद्ध्या B₅M₁M₂V₃, स्वयुक्त्या R₁V₅, (स्व)_{marg,s} बुद्ध्या R₂, स्वबुद्ध्या V₂ खिलम्] खिलां
M₁M₂ **Verse 22** not numbered B₅V₃, numbered 20 IV₂V₅, numbered 21 R₂R₃V₄
5 क्रान्तिज्या — श्लोकः] om. V₅ 6 अव्यक्ता] अव्यक्षा V₅ भयानये] भयानये V₃, भया भये V₅ न्नरतलं]
न्नतरलं M₂ संस्कार] संस्का [f] र M₁ 7 पल] फल B₅ वर्गो] कर्णो [x] B₅, वर्णो M₁M₂V₃, वक्षागो
V₅ कर्णे] वर्णे V₅ 8 कं <१२> कृति] कंकृति १४४ V₄ स्तत्समा] स्तमा M₂ 9 क्रिया] क्रिया V₄
10–12 न्यासः — ५ । ७] om. R₁V₅ 11 सूर्यः] सूर्यः रा I, सूर्या M₁M₂, सूर्यो राश्यादि R₂, सूर्यो राश्यादिः
R₃V₄, सूर्यरा V₂V₃ प्रकारेणास्य] प्रकारेण I, प्रकारेण्यास्य V₃, corrected from प्रकारेणास्य to प्रकारेण्यास्य V₄
६४ । २०] ६४ but the २० misplaced by scribe in the next verse B₅, ६४ IV₂, ६४ M₁M₂, ६४ V₄

12 ११७ । ४८] ११७ but the ४८ misplaced by scribe in the next verse B₅, ११७ IM₁M₂V₂, ११ । ७ । ४८

R₂R₃ दिग्ज्या] दिग्ज्याः M₁ ११२ । ०] ११२ B₅R₂R₃, ११२ IM₁M₂V₂ १ । ७] १ B₅M₁M₂R₂R₃,

१ IV₂, १ । ३ V₄ अक्षांशाः] अक्षांशा I ५ । ७] ५ B₅M₁M₂R₂R₃, ५ I, ५ V₂, ५ । २ V₄

अपि च ।

कन्यायाः करपीडनं प्रकुरुते पूर्वेन्द्रतुल्यप्रभो
मित्रस्तीव्रकरः सदम्बरमणिस्तारावधूमध्यगः ।

f. 18v V₄

साचार्यज्ञकवी रथाश्वनृपतिर्यस्मिन्सखे तत्पुरं
धारायाः कतियोजनैर्भवति मे तद्ब्रूहि वहेर्दिशि ॥ २३ ॥

5

सूत्रम् ।

दिङ्मौर्वी रवि १२ सङ्गुणा त्रिभगुणस्वाक्षद्युतिभ्यां हृद-
व्यक्तो ऽग्राकहतिः पलद्युतिहृता व्यक्तो ऽथ मध्यो भवेत् ।

व्यक्ताव्यक्तयमा हतिः शशियुतस्याव्यक्तवर्गस्य य-

न्मूलं हार इतीरितो हरहृतो मध्यो ऽर्धितः स्यात्फलम् ॥ २४ ॥

10 f. 14r B₅

Verse 23 not numbered B₅, numbered 21 IV₅, numbered 24 R₁, numbered 22 R₂R₃V₂
1 अपि च] उदाहरणं R₁ 2 तुल्य] तुल्या M₁M₂ प्रभो] प्रभा where the २० is misplaced and
belongs to the previous *nyāsa* B₅, प्रभा M₁M₂ 3 मित्र] मित्र R₃ स्तीव्र] स्तीव्र where the ४८
is misplaced and belongs to the previous *nyāsa* B₅ रमणिस्तारा] रमणिस्तारा V₄, रमणिःस्तारा V₅
मध्यगः] मध्य[र]गाः V₄ 4 साचार्य] साचार्य B₅, साचार्य R₂ नृपति] नृपती R₁ यस्मिन्सखे]
यस्मिन्सखे M₁M₂ तत्पुरं] तत्पुरं V₄ 5 कति] क(ति)_{marg} I योजनैर्भ] योजनैर्भ R₃ मे]
om. V₄ वहेर्दिशि] वहेर्दिशि M₁V₅ **Verse 24** not numbered B₅V₄, numbered 21 I,
numbered 25 R₁, numbered 23 R₂R₃, numbered 1 V₂, numbered 22 V₅ 6 सूत्रम्] om. V₂
7 १२] om. B₅IM₁M₂R₁V₂V₄V₅ स्वाक्ष] स्वक्ष M₁M₂, स्वाक्ष V₅ युतिभ्यां] युतिभ्यो R₂R₃
हृद] हृता V₅ 8 व्यक्तो ऽग्राक] व्यक्षा सार्क V₅ हतिः] हतिः V₄, ह^२तिः V₅ पल] फल B₅ हृता]
हिता V₅ व्यक्तो ऽथ] न्यक्तो थ M₁, व्यक्ताथ V₅ 9 व्यक्ताव्यक्त] व्यक्ताव्यक्ति R₁, व्यक्ताव्य(क्त)_{marg} V₂
यमा] मया M₁M₂ हतिः] हतेः R₂R₃, ह^२तिः V₅ शशि] शशि[त] B₅ युतस्याव्यक्त] युतसोव्यक्त
V₅ 10 मध्यो ऽर्धितः] corrected from मध्यो द्वितः to मध्यार्धितः I, मध्यो धित M₁, मध्यो धित M₂, मध्यो
द्वित(:)_{supl} R₂, मध्यादित V₅

व्यक्त|व्यासदलोत्थवर्गविवरं योज्यं फले वर्गिते
 व्य|क्ते व्यासदलाल्पके ऽधिकतरे का|र्यो वियोगस्तयोः ।
 तन्मूलं फलयुग्वियुग्घरहतं प्रागुक्तवद्गज्यका
 तच्चापांशहता चतुर्द|श|मितिः स्युर्योजनान्यन्तरे ॥ २५ ॥

p. 76 R₁
 f. 53r V₂, f. 16r R₂
 f. 17v , f. 16r b V₃

अज्ञातपत्तनपलज्यकया विनिघ्नी
 विज्ञातपत्तनपल|श्रुतिरर्कं <१२> भक्ता ।
 अग्रा भवेदिह तयान्तरयोजनज्या
 सूर्याग्रयेति यदि सेष्टदिशीह दृग्ज्या ॥ २६ ॥

5
 f. 12v R₃

अत्रार्कः ५।१०।०।० छाया १४ कर्णः १८। २६ ।लघुज्याया नरः
 १०४ क्रान्तिज्या २२।० अक्षभा २।३७ अक्षकर्णः १२।१७ उक्तवल्लब्धा
 दृग्ज्या ११८ योजनानि ६६७ ।

f. 19r V₄
 10

Verse 25 not numbered B₅V₃, numbered 22 IV₂, numbered 26 R₁, numbered 24 R₂R₃V₄, numbered 23 V₅ 1 व्यक्त] व्यक्ता I, व्यक्तं V₄ दलोत्थ] दलार्थ M₁M₂ वर्ग] वर्ग R₁ योज्यं] योज्ये R₁ 2 व्यक्ते] व्यक्तो V₄, व्यक्त्यो V₅ लाल्पके] लाल्पको V₅ कतरे] तसौ? M₁ कार्यो] कार्या V₅ 3 तन्मूलं] स्तन्मूलं V₄ युग्वियुग्घर] ग्वियुग्घर^{१२} B₅, युग्विघ्घर I, युग्वियुग्घर M₁M₂, युग्वियुग्घर V₄ हतं] हते V₅ प्रागुक्तवद्गज्यका] सौम्यान्ययोर्दृग्ज्यका IR₁, प्रागुक्तवद्गज्यका R₂, प्रागुक्तवद्ग[?]ज्यका with प्रागुक्त marked and the variant reading सौम्यान्ययो noted in margin R₃, सौम्यान्ययोर्दृग्ज्यका V₂V₅, सौप्रागुक्तवत्तयोर्दृग्ज्यका V₄ 4 तच्चापांशहता] तच्चापेन हता V₅ योजनान्यन्तरे] योजनान्यन्तरे M₁M₂, corrected from योजनानन्तरे to योजनान्यन्तरे R₂ **Verse 26** not numbered B₅V₃, numbered 23 IV₂V₅, numbered 27 R₁, numbered 24 R₂R₃, numbered 25 V₄ 5 पत्तन] पतन V₄ पल] फल IV₅ विनिघ्नी] विनि[f]घ्नी I, विभिघ्ना R₃, विनघ्नी V₅ 6 विज्ञात] ज्ञात V₄ पत्तन] प्र[भ]त्तन B₅, पत्त(न)_{marg} I पल] फल B₅ श्रुति] श्रुति R₁, [ज्यकया विनिघ्नी विज्ञातपत्तनपल]श्रुति R₃ भक्ता] भक्ता: M₁ 7 अग्रा] आग्रा V₄ योजनज्या] योजनाज्या R₁, योजनन्या V₅ 8 सेष्ट] शेष्ट V₅ दिशीह दृग्ज्या] दिशीहगदृग्ज्या B₅, दिशीहद[पू]ग्ज्या V₃ 9-11 अत्रार्कः—६६७] om. R₁V₅ 9 अत्रार्कः] अत्रार्कः B₅ ५।१०।०।०] १०।०।० R₂R₃ छाया] छाया R₂, छाया R₃ कर्णः] कर्ण(:)_{supl} R₂ ज्याया] ज्याया B₅R₂V₃, ज्या I, ज्याया: M₂V₂, ज्याया [xxxxxx] R₃ 10 १०४] १०४ I २२।०] २२ B₅M₁V₃, २२ IM₂V₂, २२।०।० R₂R₃ २।३७] २ B₅IM₁M₂R₂R₃V₂V₃ १ ३७
 अक्षकर्णः] अ(क्ष)_{marg}कर्ण I, अक्षकर्ण(:)_{supl} R₂, corrected from अक्षकर्णः to अक्षकर्णः V₂ १२।१७] १२ B₅IM₁M₂R₂R₃V₂V₃ 11 ६६७] ६६० V₂V₄ १७

भूगोलं परिकल्प्य गोलमखिलं खस्वस्तिके स्वं पुरं
तस्मादिष्टपुरं दिगंशकगते दृङ्मण्डले कल्पयेत् ।
दृग्ज्या तत्र पुरद्वयान्तरलवैस्तत्कोटिजीवा नरो
बाहुस्तत्सममण्डलान्तरलवाः शङ्कोस्तलं साग्रका ॥ २७ ॥

|अपसरलवमौर्व्या त्रिज्यया दिग्ज्य|का दो-

5 f. 53v V₂, f. 20r

V₅

रपसृतिलवमौर्व्याव्यक्त्या किं तदा स्यात् ।
फलमितभुजहीना संयुता वाग्रका स्या-
न्नरतलमिह सौम्ये याम्यभागे क्रमेण ॥ २८ ॥

|यदि रविमितकोटि|: स्वाक्षभायास्तदा का
नरतलमितबाहौ कोटिजीवात्र |लब्धम् ।
अविदितभुजजीवावर्गहीनस्त्रिवर्गो
ह्यपसृतिलवकोटिज्याकृतिः पूर्वको द्याः ॥ २९ ॥

f. 18r I, p. 77 R₁

10 f. 16v R₂

Verse 27 not numbered B₅V₃, numbered 34 I, numbered 28 R₁, numbered 26 R₂R₃V₄,
numbered 24 V₂V₅ 1 भूगोलं] भूगो M₂, (अपि च)_{marg,s} भूगोलं R₂ परिकल्प्य] परिकल्प्य
B₅, परि(क)_{marg} लपं V₃, परिकल्प V₅ गोल] शोल R₂R₃ खस्वस्तिके] स्वस्तिके B₅, स्वस्तिके
M₁M₂ 2 तस्मादि] ततस्मादि V₃ पुरं] पुरे V₅ दिगंशक] दिशांशक V₅ दृङ्मण्डले] दृङ्मण्डले
B₅, दृङ्मण्ड [x](ले)_{marg,s} R₂, दृङ्मण्डले R₃ 3 दृग्ज्या] दृग्जा M₁ पुरद्वयान्तर] पुरद्वयांतर (र)_{supl} I, पुरं
पुरांतर V₅ जीवा] जीवां V₅ 3-4 नरो बाहु] नरैर्बाहु R₁ 4 लवा:] लवा V₅ शङ्कोस्तलं] शकोस्तले
R₁ साग्रका] साग्रका: B₅M₁M₂R₁, साग्रका[:] V₃ **Verse 28** not numbered B₅V₃,
numbered 25 I, numbered 29 R₁, numbered 27 R₂R₃V₄, numbered 26 V₂ 5 अपसर] अपसर
अपस M₂, अपसर V₄, अथ सार V₅ लव] ल(व)_{marg} I दिग्ज्यका] दृग्ज्यका B₅IM₁V₄, दृग्ज्यया
दृग्ज्यका M₂, corrected from दिग्ज्यको to दिग्ज्यका V₃ दो] दौ I 6 लव] जव V₅ मौर्व्याव्य]
मौर्व्याव्य IV₂V₄, (मौ)_{marg,s} व्याव्य R₂ क्त्या] क्त्वा R₃ किं] कि V₄ 7 मित] निति R₁
8 तलमिह] ललमिह V₄ भागे] भागे B₅, भाग R₁ **Verse 29** not numbered B₅M₁V₃,
numbered 26 IV₂, numbered 30 R₁, numbered 28 R₂R₃V₄ 9 मित] मिति R₃, मित V₅
भायास्तदा] भाया तदा R₁ 10 नर] नर V₃ मित] मिति R₁ बाहौ] corrected from बाहु to बाहौ
V₄ 10-11 कोटि—वर्गों] om. R₁ 10 कोटि] को(टि)_{marg} I, corrected from कौटि to कोटि M₁
जीवात्र] जीवात्र V₅ 11 अविदित] अ[र]विदित V₃ भुज] भु B₅, (भुज)_{marg} I हीनस्त्रि] हीनास्त्रि
V₅ वर्गों] वर्गों V₄ 12 ह्यपसृति] ह्यपराति R₂R₃, ह्यपसृति V₅ लव] ल(व)_{marg} I कोटिज्या]
कोटिज्या B₅M₂, कोटि[जीवात्रलब्ध] ॥ अविदितभुजजीवा] ज्या I, कोटिज्या R₂, कोटि: ज्या V₅ कृति:] कृति V₅
पूर्वको] पूर्वको I द्या:] द्या V₅

।कृत्या समेति हि समीकरणे प्रयोज्या
बीजक्रियापसरभागभुजज्यकार्थम् ॥ ३० ॥

f. 14v B₅

।अपि च ।

f. 19v V₄

रामारातिपुरात्पुरारिहरितं रामाङ्कभागाश्रिते
सन्मित्रे ऽस्तमिते गतः स हनुमञ्छल्याविशल्येच्छया ।
दृष्टातिष्ठदथाद्रि।तुल्यपदभां श्रीकण्ठकाष्ठोन्मुखीं
तद्यानं वद कोविदेन्दुकलिकासञ्जीवने ऽर्को ऽसि चेत् ॥ ३१ ॥

5

f. 5v M₁, f. 16v V₃

।अत्र सायनार्कः ५।९।०।० क्रान्तिज्या २२।४८ अक्षभा ११।४८
लब्धयो।जनानि ९८०

f. 54r V₂

f. 13r R₃

Verse 30 not numbered B₅R₁R₂R₃V₃, numbered 27 IV₂V₅, numbered 29 V₄ 1 कृत्या]
कृत्वा R₁V₂ समेति] सनेति R₂R₃ हि] ह R₁ 2 भुज] मुज R₃ ज्यकार्थम्] ज्यकार्यम् R₂R₃,
स्य कथ V₅ **Verse 31** not numbered B₅V₂V₃, numbered 28 IV₅, numbered 29
R₂R₃, numbered 30 V₄ 3 अपि च] उदाहरणं R₁, om. V₅ 4 रामारातिपुरा] marked and
the annotation लंकातः added in margin by s R₂, marked and the annotation लंकातः added
in margin R₃, रामारातिपुरा V₄ तुरारिहरितं] पुरानुरारिहरितं B₅V₃, marked and the annotation
ईशानदिशं added in margin by s R₂, marked and the annotation ऐशनो added in margin R₃
रामाङ्क] रामांक ९ I, रामांक ९३ R₂R₃ 5 सन्मित्रे] corrected from सेन्मित्रे to सन्मित्रे V₄ ऽस्तमिते]
स्तगते R₁, स्वगते R₂R₃ गतः] गत M₂, गते गतः V₅ हनुमञ्छल्या] हनुमाछल्या M₁M₂ विशल्ये]
विशेल्ये B₅ च्छया] क्षया R₁ 6 दृष्टा] दृष्टा R₁ तिष्ठदथा] तिष्ठ तथा V₅ थाद्रि] थाष्ट V₅
पदभां] पदलां B₅, पलभां IV₄V₅ काष्ठो] corrected from कोष्ठो to काष्ठो B₅ न्मुखीं] न्मुकी V₃V₄V₅
7 कलिका] तिलका V₂ सञ्जीवने] संजीवनो R₂, जीवने V₅ ऽर्को] को V₄V₅ 8-9 सायनार्कः—९८०]
om. R₁V₅ 8 सायनार्कः] साधनार्कः V₄ ५।९।०।०] ५ I, (२९।०।०।०)_{marg} V₂, om. V₄

क्रान्तिज्या] कान्तिज्या R₃ २२।४८] २२ I ११।४८] ११ V₂V₄ 9 लब्ध] लब्ध M₁M₂
४८

|अपि च ।

f. 19v V₄

सिंहासनस्थं समवृत्तभुक्त्या
पुरन्दराशां परिपूरयन्तम् ।
ज्ञाते पुरे विष्णुपदे नमन्तं
पश्यामि मित्रं समयेन केन ॥ ३२ ॥

5

|सूत्रम् ।

f. 18v I

सूर्याग्रया कथितवत्परिसाधनीया
दृग्ज्या तयाभिमतदिग्द्युति नाडिकाश्च ।
इच्छादिशं विशति तासु घटीषु भास्व-
च्छाया तयाभिमतदिक्परिसाधनीया ॥ ३३ ॥

10

Verse 32 not numbered B₅V₂V₃, numbered 29 IV₂V₅, numbered 31 R₁V₄, numbered 30 R₂R₃ 1 अपि च] om. V₅ 2 स्थं समवृत्तभुक्त्या] संस्थमवृत्यगत्या V₅ भुक्त्या] गत्य R₂R₃, भुक्त्या [९]V₂ V₂, भुक्त्य ९०० V₄ 3 पुरन्दराशां] पुरंदराशी M₁, पुरंद शो रं M₂ परिपूरयन्तम्] परिपूरयंत
:
V₄, परिपूरयन्नतं V₅ 4 पदे] मते M₁M₂ नमन्तं] नयंतं M₁, नयतं M₂, नमंत V₅ 5 पश्यामि] दृक्ष्यामि R₁, दृक्ष्यामि R₂R₃V₅, पश्यामि V₄ समयेन] समयेत V₄ **Verse 33** not numbered B₅V₂V₃, numbered 30 IV₅, numbered 32 R₁V₄, numbered 31 R₂R₃ 6 सूत्रम्] om. V₅ 7 वत्परि] वत्परि B₅, वत्परि R₂R₃V₃, रत्परि V₅ 8 दृग्ज्या] corrected from दिग्ज्या to दृग्ज्या V₂ मत] मति V₃ 8-10 दिग्द्युति—आभिमत] om. M₂ 8 दिग्द्युति] दिग्द्युति M₁R₂R₃V₅, दृग्द्युति R₁ नाडिकाश्च] नाडिकासु R₂R₃ 9 इच्छा] इच्छं B₅V₃, इत्थं M₁R₂R₃, इत्था V₄ दिशं विशति तासु] विशत्यविदितासु R₂R₃, दि विशति तासु V₃, दिशं विशति तासु V₄, दिशं विदिश तासु V₅ घटीषु] घटीसु R₁ 9-10 भास्वच्छाया तया] भास्वच्छायानया B₅IM₁V₂, भास्वान्स्वच्छाया R₂R₃, भास्वच्छायानया V₃V₄, भास्वच्छायानया V₅ 10 भिमत] मत B₅ दिक्परिसाधनीया] दिक्परिसाधनीया B₅, दिक्परिकल्पनीया R₁V₅

अपि च ।

गोदातीरगतात्मतीर्थविषये सत्र्यंशवेदाक्षभे

भानोर्भा हरिसङ्गतस्य हरदिग्भागाश्रितां ब्रूहि मे ।

त्र्यंशोनाङ्गमिताक्षभापि शिवदिक्काशी कियद्योजनै-

रेकेनानयनेन तद्वद सखे वाञ्छामि वाराणसीम् ॥ ३४ ॥

f. 17r R₂

f. 17r R₂

5 f. 20r V₄

अत्रार्कः ४।१५ क्रान्तिज्या ४७।४९ दिग्ज्या ११२ अव्यक्तः १।५६

व्यक्तः १३२।२५ मध्यः ५१०।४० हारः २।७ फलम् १२०।४० मूलम्

१५० दृग्ज्या ३० छाया १।८

f. 54v V₂

अथानेन प्रकारेण अन्तरयोजनज्यासाधनं तत्र । काश्यामक्षभा ५।४०

कर्णः १३।१७ अक्षज्या ६८।१२ अव्यक्तः १।५६ अग्रा ७२।२७ व्यक्तः

२००।३८ हारः २।८ मध्यः ७७५।१४ फलं १८१।३० मूलं १३८।०

दृग्ज्या २३।३० अतो अन्तरयोजनानि १२६

10 f. 15r B₅

f. 19r I, f. 17r V₃

Verse 34 not numbered B₅V₂V₃, numbered 31 I, numbered 35 R₁, numbered 32 R₂R₃,
numbered 31 R₂R₃, numbered 33 V₅ 1 अपि च] om. I, उदाहरणं R₁ 2 सत्र्यंश] त्र्यंश V₄
क्षभे] क्षभे ४।२० V₅ 3 भा] भा M₁V₅ हरदिग्भा] शिवदिक्भा R₁ 4 त्र्यंशोनाङ्ग] अंशोनाङ्ग B₅R₁
क्षभापि] क्षभा ६।२० पि V₅ कियद्योजनै] कियद्योजने B₅M₁, कियद्योजनै V₅ 5 रेकेनानयनेन] रेकानानयनेन
R₁ तद्वद] तद्वद I, तद्वस M₁ वाञ्छामि] वाञ्छामि M₁ वाराणसीम्] वाराणसी M₁, वाराणसी V₅
6 अत्रार्कः] अत्रार्कः I ४।१५] ४।१५।० R₂R₃ ४७।४९] ४७ V₂ ११२] ११२ V₄ अव्यक्तः]

अव्यक्त I, अव्य V₂V₄ १।५६] १ V₂, १ ५६ V₄ 7 १३२।२५] १३२ I, १३२ V₂V₄ मध्यः] मध्यमः V₂,
२५

मध्य(:)^{supl} V₃ ५१०।४०] ५१० R₂R₃, ५१० V₂, ५२०।४० V₄ २।७] २।८[?] B₅, २ V₂ मूलम्] मूल
४०

V₃ 8 १५०] १०।५० R₂R₃ छाया] छाया V₃, छायेयं V₄ १।८] १ B₅M₁M₂R₂R₃V₃, १० V₂, १।
८

० V₄ 9-12 अथानेन—१२६] om. R₁V₅ 9 अथानेन] अथान्य V₄ प्रकारेण अन्तर] प्रकारेणांतर R₂R₃
ज्यासाधनं] ज्यासाधनां R₃, ज्या V₄ काश्यामक्ष] काश्या अक्ष R₁V₅, काश्या (मक्ष)^{marg} प्र[भक्ष]भा V₂ ५।
४०] ५ V₂ 10 कर्णः] अक्षकर्णः R₂R₃, कर्ण V₃ १३।१७] १३ V₂ ६८।१२] ६८ V₂, ६८।१२ V₄
४०

१।५६] १।५६ B₅, १ V₂ ७२।२७] ७२ V₂V₄ 11 २००।३८] २०० ३० B₅, २०० V₂V₄ २।८]
५६

० (1)^{supl} २।०।८ R₂, ० २।०।८ R₃, ३ V₂, २।२।८ V₃, ३।८ V₄ ७७५।१४] ७१५।१४ B₅, ७७५ V₂
१८१।३०] १८१।१० B₅, ८१।३० M₁M₂, १८१ V₂V₄ १३८।०] १३७ B₅, १३।० M₁M₂V₃, १३।२७ R₂R₃,
१३८ V₂, १३८।३० V₄ 12 दृग्ज्या] दृग्ज्या R₃, ज्या V₂V₄ २३।३०] २३।२० R₂R₃, २३ V₂, ३३ V₄
योजनानि] योज[R]नानि B₅, योजनानि R₃ १२६] २६ R₂R₃, १२२६ V₂V₄

सूत्रम् ।

अपसरांशककोटिगुणो ऽर्कह -

त्पलभया गुणितः परिसंस्कृतः ।

निगदिताग्रकया त्रिगुणा हतो

ऽपसरदोर्गुणहृत्खलु दिग्ज्यका ॥ ३५ ॥

f. 13v R₃

5

अपि च ।

धारापुरे दिनकरे मकरे ऽन्धकारे

चौरो ऽहरन्नृपतुरङ्गवरं गतो ऽरम् ।

साशीति पञ्चशतयोजनगो ऽर्कतुल्यां

पूर्वप्रभां गणयति स्वदिशा भ्रमेण ॥ ३६ ॥

p. 78 R₁

10

रविः ९।०।०।० क्रान्तिज्या ६५ छाया १२ कर्णः १७ यथोक्तकरणेन
लब्धा दिग्ज्या ११२

f. 17v R₂

Verse 35 om. IM₁M₂V₃V₄ not numbered B₅, numbered 34 R₁R₂R₃, numbered 32 V₅ 1 सूत्रम्] अथ सूत्रं R₂R₃, अपि च सूत्रं V₂, om. V₅ 2 अपसरांशक] अपसराशक B₅, अपरांसव V₅ 3 त्पल] corrected from त्फल to त्पल V₂ परिसंस्कृतः] परसंस्कृतः R₂R₃ 4 त्रिगुणा] त्रिगुणा ३४३८ R₂R₃ 5 दोर्गुण] दोलर्गुण R₁ दिग्ज्यका] दिग्ज्यका V₂V₅ **Verse 36** not numbered B₅V₂V₃, numbered 32 I, numbered 35 M₁M₂, numbered 33 R₁R₂R₃, numbered 34 V₄, numbered 31 V₅ 6 अपि च] om. B₅IM₁M₂V₃, उदाहरणं V₄ 7 धारा] धाधारा V₄ ऽन्धकारे] धकारे B₅ 8 चौरो] चोरो B₅M₂R₃V₂V₃V₄, चारो M₁ ऽहरन्नृप] हरं नृप M₁M₂, हरेन्नृप R₂ तुरङ्गवरं] तुरेगवरं R₃, तुरं(गवरं)^{marg} V₃ गतो ऽरम्] गतो ऽरं B₅, स वेगात् R₁R₂R₃V₂ 9 साशीति] सासीति B₅V₃, साशीत R₁V₅ पञ्चशत] पंचमित B₅, पंचमित M₁M₂V₃, पंच ५८ शत R₂, पंच ५८ मित R₃, corrected from पंचशते to पंचशत V₄ ऽर्क] क B₅ तुल्यां] तुल्या M₁V₄ 10 पूर्व] सर्व R₂R₃ प्रभां] प्रत्वा[?]भां B₅ गणयति स्वदिशा] गणयतीष्टदिशा B₅, गणयतीष्टदिशा M₁, गणयातीष्टदिशा M₂R₂R₃, गणयति स्मदिशा R₁, गणयतीष्टदिशा V₃, गणयाति दिशा V₅ भ्रमेण] क्रमेण R₂R₃ 11 रविः] अत्र रविः R₂, अत्र रविः R₃ ९।०।०।०] ९।०।० B₅, ९।० IM₁M₂V₂V₃V₄ कर्णः] कर्ण R₂, कर्ण R₃ यथोक्तकरणेन] यथोक्तकरणेन B₅ 12 ११२] ११ B₅, om. I

अथ कालसाधनम् ।

गोलक्रमाच्चरदलज्यकया युतोना

त्रि।ज्या तथावनिगुणेन निजद्युजीवा ।

f. 55r V₂, f. 20v V₄

अन्त्याहृती तरणिबिम्बनिजोदयास्त-

सूत्रान्तरे परिणते त्रिगुणद्युमौर्व्योः ॥ ३७ ॥

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गोलक्रमाद्दिनदले स्वपलापमांश-

विश्लेषयोगभुजकोटिगुणौ विधेयौ ।

दृग्ज्यानरौ नरह।तार्कगुणात्र दृग्ज्या

f. 15v B₅

छाया तदर्क १२ कृतियोगपदं श्रुतिः स्यात् ॥ ३८ ॥

Verse 37 not numbered B₅V₂V₃, numbered 33 I, numbered 36 M₁M₂R₁, numbered 34 R₂R₃V₅ 1 अथ कालसाधनम्] सूत्रं R₁, om. V₅ साधनम्] सोधनं B₅ 2 गोल] गोभ R₁ दलज्यकया] दज्यकया B₅, दलज्यकाया R₁, दलज्ज्यकया V₂ 3 तथावनि] थवावनि R₁, तथा (ऽ)^{supl}वनि R₃, तथावनि R₃ वनिगुणेन] marked and the annotation कुज्यया added in margin by s R₂ गुणेन] गुणेय R₁, गुणे V₅ निज] निजा M₁M₂, निजं R₁ द्युजीवा] भुजं वा R₁ 4 अन्त्या] अन्या M₂ तरणि] तरण V₅ बिम्ब] बिब B₅, बिं x V₅ निजो] नियो M₂ दयास्त] जयास्त M₂, दयास्तु R₁ 5 सूत्रान्तरे] त्सूत्रान्तरे M₂ परिणते] परिणतै R₁, परिण V₄, परिणते V₅ त्रिगुणद्यु] त्रिगुणाद्य B₅M₁M₂R₃V₃, त्रिगुणाद्यु R₂V₅, द्यु V₄ मौर्व्योः] मौर्व्यां B₅M₁M₂R₂R₃V₃V₅, मौर्व्याः R₁, मौर्व्याः V₂V₄ **Verse 38** not numbered B₅V₂, numbered 34 I, numbered 37 M₁M₂R₁, numbered 35 R₂R₃V₅, numbered 5 V₃, numbered 36 V₄ 6 गोल] गोल [x] V₃ क्रमाद्दिन] क्रमा दिन V₅ दले] गुणे: V₅ स्वपला] स्वप (ला)^{supl} I, स्वप M₁, स्वपलं M₂, स्वपला R₃, खमला V₅ पमांश] पमाशा B₅ 7 योग] corrected from योगे to योग V₄ 8 दृग्ज्या] दिग्ज्या V₂, दृमा V₅ नरौ] नशै B₅, वशै M₁, दशै M₂ नर] न (र)^{margin} I हतार्क] हतार्व B₅, हताऽर्क I, corrected from हतो to हता M₂ 9 छाया] छाप R₁ १२] om. R₁R₂R₃V₅ पदं] परं R₁ श्रुतिः] शृति R₁, श्रुति (:)^{supl} R₂

मध्यान्त्यका द्युनिशवृत्तनतासु वाम -
जी।वोनिता निगदिताभिमतान्त्यकासौ ।
द्युज्याहता त्रिभगुणेन हता हतिः स्या -
त्सार्काहता स्वपलकर्णहृदिष्टशङ्कुः ॥ ३९ ॥

p. 79 R₁

भास्वद्गुणात्त्रिभगुणान्तरलब्धमिष्ट -
छाया श्रुतिर्भवति वाममतो नतं स्यात् ।
भास्वद्गुणात्त्रिभगुणात्श्रुतिलब्धमिष्ट -
शङ्कुः पलश्रुतिगुणो ऽर्कहतो हतिः स्यात् ॥ ४० ॥

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इष्टा हतिस्त्रिभगुणेन हता द्युजीवा -
भक्तान्त्यका।थ पतितद्युदलान्त्यकायाः ।
शेषस्य वामधनुरेव न।तासवः स्यु -
स्तद्वर्जितं द्युदलमुन्नतनाडिकास्ताः ॥ ४१ ॥

f. 55v V₂

10

f. 19v I

Verse 39 om. B₅M₁M₂V₃ numbered 38 R₁, not numbered V₂, numbered 37 V₄, numbered 36 V₅ 1 मध्यान्त्यका] मध्याक्तका V₅ द्युनिश] द्युनि R₁, द्युतिश R₃ वृत्त] वृत्त(ग)_{marg,s} R₂, वृत्तल R₃ 2 जीवोनिता] जीवोनि V₄, जीवोनता R₃ निगदिता] गदिता V₄ भिमतान्त्य] मितितांत्य R₁, मितांत्य V₄ 3 हता] हता R₁V₅ हतिः] हति(:)_{supl} R₂ 4 त्सार्का] त्वाका R₂, त्वांका R₃, कां V₄, त्वाकां V₅ हता] हता R₁V₂V₅ स्व] स्व[x] V₂ **Verse 40** om. B₅M₁M₂V₃ numbered 38 R₁, not numbered V₂, numbered 37 V₄, numbered 36 V₅ 5 भास्व] भास्वे R₂ 6 श्रुतिर्भ] श्रुतिर्भ R₁R₃ 7 भास्व] भास्वे R₂ 8 श्रुति] श्रुति R₁ **Verse 41** not numbered B₅R₁V₂V₃, numbered 35 I, numbered 38 M₁M₂V₄V₅, numbered 36 R₂R₃ 9 स्त्रिभगुणे] स्त्रिभगुणेन ३४३८ B₅IM₁M₂R₂R₃V₂V₃, स्त्रिभगुणे ३४३८ V₄, स्त्रिभगुणान V₅ हता] हता V₅ 10 काथ] काव्य R₁, काथ [कथि] V₂, काप V₄ पतित] पतिता IV₄V₅, पतितं R₂R₃ दलान्त्य] दलांत B₅M₁M₂R₁V₃ कायाः] कानाः V₄ 11 वामधनु] marked and the annotation उत्क्रमधनु added in margin by s R₂ रेव] जेव V₅ सवः] सव M₁M₂ स्यु] स्या V₅ 12 स्तद्वर्जितं] स्तद्वर्जितं B₅, स्तवर्जितं R₁, स्तद्वर्जितं V₄, स्तद्वर्जितं V₅ नाडिकास्ताः] नाडिकाः स्युः B₅M₂R₃V₃, नाडिका स्युः M₁, ना (डिका)_{marg} R₂

।याम्योदग्व।लयद्युरात्रवल्यस्पर्शे दिनार्धं ततो
 ऽप्यन्त्यास्तोदयसूत्रगा हृतिरपि द्वे कर्णरूपे स्मृते ।
 लङ्कास्वोदयसूत्रयोश्च विवरे कुज्या चरज्याथ वा
 द्युज्यात्रिज्यकयोस्तदूनयुतयोर्हृत्यन्त्यके गोलयोः ॥ ४२ ॥

f. 21r V₄, f. 18r R₂

मध्येष्टान्त्यकयोर्नतोत्क्रमगुणः स्यादन्तरं तेन सा
 हीनान्त्याभिमता भवेद्धृतिरियं द्युज्याख्यवृत्ते कृता ।
 कोटिश्चेत्पलकर्णके रविमिता तत्किं हृतौ स्यान्नर-
 स्त्रिज्या तेन यदा श्रुती रविमिते शङ्कौ किमिष्टा श्रुतिः ॥ ४३ ॥

5 f. 14r R₃

f. 17v V₃

त्रिज्याधिकस्य यदि वामधनुर्विधेयं
 त्रिज्यां विशोध्य परिशेषधनुः क्रमेण ।
 संयोजितं शतगुणार्णवबाण ५४०० सङ्घौः
 स्याच्चापमुत्क्रममयं गुणचापयुक्त्या ॥ ४४ ॥

10

f. 16r B₅

Verse 42 not numbered B₅V₂, numbered 36 I, numbered 39 M₁M₂V₅, numbered 41 R₁, numbered 37 R₂R₃ 1 याम्यो] (अत्रोपपत्तिः) marg,s R₂, योम्यो V₅ ग्वलय] ग्वलनं M₁M₂, ग्वल(ये) marg V₂, ग्वल V₅ रात्र] रात्रि R₁ वलय] वल⁻ B₅ स्पर्शे] स्पर्शो M₁, स्पशो V₅ दिनार्धं] दिनार्धं M₁M₂, दिनार्धं R₃, दिनार्द्धं V₄, दिनार्द्धं V₅ 2 ऽप्यन्त्यास्तोदय] ह्यन्त्यास्त्वोदय R₁, (ऽ)supl प्यन्त्यास्त्वोदय with प्यं marked and प्यं added in the margin by s R₂, प्यन्त्यास्तोदय[नाडी] V₂, ह्यन्तांस्वरेदय V₅ हृतिरपि] धृतिरपि V₅ कर्णरूपे] कर्णसूत्रे R₁ स्मृते] स्मृतिः V₅ 3 लङ्कास्वोदय] लंकास्त्वोदय R₁, लंका(ऽ)supl स्तोदय R₂, लंकास्त्वोदय R₃, लंकोस्त्वोदय V₅ सूत्रयोश्च] स्तत्रयोश्च R₁ ज्याथ] ज्या(ऽ)supl थ R₂, ज्याऽथ R₃, ज्यांथ V₄ 4 युतयो] कतयो B₅ हृत्यन्त्यके] हृत्यन्तके B₅M₁M₂V₃V₄, हृत्यन्त्यके R₁, हृत्यान्त्यके R₂R₃ गोलयोः] corrected from गोलयेः to गोलयोः R₂, गोलयेः R₃ **Verse 43** not numbered B₅V₂V₃, numbered 37 I, numbered 40 M₁M₂, numbered 42 R₁, numbered 38 R₂R₃ 5 शान्त्य] शान्त्य B₅, शान्त M₁ नतो] नते B₅, नतो M₁M₂V₄ गुणः] गुण IM₁M₂ दन्तरं] दन्तरे R₁ तेन] तन M₂, तन R₁ सा] ता R₁ 6 हीनान्त्या] हीनात्या M₂ भिमता] भमता R₁ दृति] दृति R₁ द्युज्याख्य] द्युज्या B₅, द्युज्या(ख्य)supl V₃ वृत्ते] वृत्ते B₅ कृता] कृताः B₅M₁M₂V₃ 7 कर्णके] कर्णके V₃ तत्किं] तकिं V₅ हृतौ] गतौ V₄ 7-8 न्नरस्त्रिज्या] न्नरास्त्रिज्या B₅ 8 यदा] यतः V₅ श्रुती] श्रुती M₁, श्रुती R₁, श्रुति R₂ श्रुतिः] श्रुति M₁, श्रुतिः R₁ **Verse 44** not numbered B₅V₂V₃, numbered 38 I, numbered 41 M₁M₂, numbered 39 R₂R₃, numbered 42 V₄, numbered 41 V₅ not found R₁ 9-11 वाम—बाण] om. but added in margin V₃ 10 त्रिज्यां] त्रिज्यो M₂ विशोध्य] विशोध्यं V₅ धनुः] धनुः(ः)supl IR₂ 11 संयोजितं] संयोजित(ः)supl R₂, संयोजित R₃ शत] सत R₂R₃ ५४००] संख्यैः ५४०० B₅M₁M₂V₃, om. V₅ सङ्घौः] संख्यै I, corrected from संख्यौ to संख्यै V₄ 12 मयं गुण] गुणस्य च V₅ युक्त्या] युक्त B₅, युक्ता V₅

यत्सिद्धा|न्तशिरोमणौ समुदितं मध्यान्त्ययोन्ना हतः

f. 20r I

सम्भक्तश्चरजीवया दिनदले शङ्कुर्भवेद्वाथ सः ।

अक्षक्षेत्रजकोटिभिर्विगुणितस्तत्कर्णभक्तो हति -

f. 21v V₄

स्त|त्सर्वं विषुवद्दिने व्यभिचरत्यस्मान्मया नोदितम् ॥ ४५ ॥

इत्थं श्रीमन्नागनाथात्मजेन

5

प्रोक्ते तन्त्रे ज्ञानेराजेन रम्ये ।

ग्रन्थागाराधारभूते प्रभूते

त्रिप्रश्नो ऽयं कालदिग्देशसिद्धौ ॥ ४६ ॥

Verse 45 not numbered B₅V₂, numbered 39 I, numbered 42 M₁M₂V₅, numbered 43 R₁V₄, numbered 40 R₂R₃, numbered 69 V₃ 1 त्सिद्धान्त] त्सीद्धान्त V₅ शिरोमणौ] शिरामणौ I समुदितं] समुणौ समुदितौतं V₅ मध्यान्त्य] मध्यान्त B₅M₁M₂V₄, मध्यान्त V₃, मध्यान्त V₅ योन्ना] योना R₂, याना V₅ हतः] ह B₅, हताः R₁, हतेः V₅ 2 सम्भक्त] स भक्त V₃ शङ्कुर्भ] शङ्कुर्भ V₃, शङ्कु भ V₄V₅ द्वाथ सः] द्वाय सः M₁M₂R₃, द्वाथ वा R₁V₅, द्वा (ऽ)^{supl}थ सः R₂, द्वाश सः Vfo 3 अक्ष] अ V₅ क्षेत्रज] क्षेत्र (ज)^{marg,s} R₂, क्षत्र V₄ विगुणित] विगुणिता R₂R₃, गुणि V₄ भक्तो] भक्ता R₂R₃ हति] कृति B₅M₁M₂V₃, हतः V₅ 4 त्सर्व — नोदितम्] त्कर्णभक्तो हतिस्तत्सर्व V₄ त्सर्व] त्सर्व R₁ विषुवद्दिने] with दिने marked and the variant reading added in the margin by s R₂ चरत्यस्मा] चरत्य (ऽ)^{supl}स्मा R₂ **Verse 46** not numbered B₅IV₂V₃, numbered 43 M₁M₂, numbered 44 R₁, numbered 41 R₂R₃, numbered 3 V₄, numbered 2 V₅ 5 इत्थं] इच्छं V₅ नागनाथा] नागराजा R₁, नागनाथ V₃ 5-7 जेन — प्रभूते] om. M₁ 6-7 प्रोक्ते — प्रभूते] om. V₅ 6 प्रोक्ते] प्रोक्त V₄ तन्त्रे] तन्त्रे V₃ रम्ये] रम्यो V₄ 7 ग्रन्था] ग्रथा V₃ प्रभूते] प्रभूवे V₃ 8 त्रिप्रश्नो] त्रिप्रश्ने R₁V₅ ऽयं कालदिग्देशसिद्धौ] दिग्देशकालादिसिद्धौ R₁V₅, यं कालदिशसिद्धौ R₃ **Colophon** इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीमद्ज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः B₅, इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीमद्ज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः I, इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीमद्ज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः M₁, इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीमद्ज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः M₂, no colophon R₁, (इति श्रीनागराजात्मजज्ञानराजविरचिते सिद्धांतसुंदरे गणिताध्यायये त्रिप्रश्नाधिकारस्तृतीयः)^{marg,s} R₂, no colophon R₃, इति त्रिप्रश्नाध्यायः V₂, इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीमद्ज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः V₃, इति श्रीमत्सकलवासनाविचारचतुरचित्तचमत्कारिणि श्रीज्ञानराजविरचिते सिद्धांतसुंदरे त्रिप्रश्नाध्यायः V₄, no colophon V₅

〈अथ ग्रहगणिताध्याये पर्वसम्भूत्यधिकारः〉

।रामैः ३९ खगुणै ३० र्जिनैः २४ शशियमै २१ व्यंशं चतुर्धा नखै २० । २० । २० । २० - f. 8r M₂

राकृत्या २२ झयमैः २६ सुरैः ३३ शरयुगै ४५ स्त्र्यश्चै ७३ द्विशत्या २०० निलात् ।

सांशं खाभ्रयुगैः । ४०० शतेन १०० खरसै ६० स्तानै ४९ स्त्रिधाब्ध्यब्धिभि ४४ । ४४ । ४४ - f. 20v I, f. 56v V₂

द्व्यक्षै ५२ द्व्यद्रिमितै ७२ रदेन्दुभि १३२ रयुक्खेने ० न्द्रचन्द्रैः ११४ पलैः ॥ १ ॥

Verse 1 2-5 गोरमैः—निलात्] marked and the annotation अश्विन्यादिगतरवेवांरादि गोरामैरित्यादिपलैर्भक्त्वा?शादिफलं चित्रावधिव्यंशं । परतः सांशं स्वातेः प्रारभ्य पूर्वाभद्रपदा यावत् । ततो ऽयुक् उभरेवत्योः added in the margin V₂ 2 रामैः] रमै V₃ गुणै] गुणैः V₅ र्जिनैः] दिनै V₅ यमै २१ व्यंशं] ययै २१ व्यंशं I, यमैः २१ व्यंशं V₂, यमैः २१ व्यंशं V₅ चतुर्धा] चतुर्द्धी V₄ नखै] नखैः M₁V₂V₅ 3 २० । २० । २० । २०] २० R₂R₃ 4 २२] om. V₃V₄ यमैः] यमै M₁R₁V₃ २६ सुरैः] om. V₄ २६] corrected from ३६ to २६ B₅ युगै] युगैः V₄V₅ ४५] [५]४५ M₁ चै ७३ द्वि] चै ७३ द्वि V₄ द्विशत्या २००] द्विशत्या २० द्विशत्या २०० V₅ शत्या] रात्या R₃ 5 निलात्] निला [ह]त् B₅, निलात् M₁M₂ 6 सांशं] सांश V₃, सांश V₅ खाभ्र] corrected from खभ्र to खाभ्र R₂ युगैः] युगै B₅M₂R₁, युज्यै? V₅ खरसै] खरसैः V₄ ४९] corrected from ४१ to ४९ V₄ स्त्रिधा] स्त्रिभा M₁ ब्यब्धिभि] ब्यब्धिभिः (:) ^{supl} I, ब्यब्धिभिः M₁, ब्यब्ध्यभिः M₂, ध्याब्धिभि R₁, (ऽ) ^{supl} ब्यब्धिभि R₂, द्यब्धिभिः V₄, व्यब्धिभि V₅ 7 ४४ । ४४ । ४४] ४४ । ४४ I 8 द्व्यक्षै ५२] द्व्यक्षै [x] ५२ B₅, द्व्यक्षै I, om. M₂V₄ द्व्यद्रिमितै] द्व्यद्रिमितै R₃, द्व्यद्रिसितै V₅ ७२] द्व्यद्रि ७२ M₁ रदेन्दुभि] रदेधुभि M₁, रगेदुभि R₂, ररोदुभि R₃, रदेन्दुभिः V₄, रदेदु V₅ १३२] १३५ V₄ रयुक्खे] रसयुक्खे V₅ ०] om. B₅IM₁M₂R₁V₂V₄V₅, नें ० द्र R₂R₃V₃ ११४] पलैः ११४ M₁M₂ Belonging to verse 1 is a table on p. 80 R₁:

अ० ३९ ऋ०	भ० ३०	कु० २४	रो० २१	मू० २०	आ० २०	पु० २०	पु० २०	अ० २२	म० २६	पू० ३३	उ० ४५	ह० ७३	चि० २०० ऋ०	स्वा० ४०० ध०	वि० १००	अ० ६०
ज्ये० ४९	मू० ४४	पू० ४४	उ० ४४	अ० ५२	ध० ७२	श० १३२ ध०	पू० ७ ऋ०	उ० ११४	रे० ०	नक्षत्रा० अंकानि	Belonging to verse 1					

is a table in R₂ added by s:

अ० ३९	भ० ३०	कु० २४	रो० २१	मू० २०	आ० २०	पु० २०	पु० २०	उ० ४५	ह० ७३	चि० २००	स्वा० ४००	वि० १००	अ० ६०
उ०फा ४५	ह० ७३	चि० २००	स्वा० ४००	वि० १००	उ० ६०	ज्ये० ४९	मू० ४४	पू० ४४	षा० ४४	उ०षा०	अ० ध०	श०	
पुभा०	उ०भा०रे												

।वाराद्यं रविभाद्रतं दिनमणिः स्याद्भुक्तराश्यादियु-

p. 81 R₁, f. 21r V₅

क्पर्वान्ते ऽस्य गतिर्दिनादथ फलं ।पात।स्य लिप्ता।मयम् ।

f. 22r V₄, f. 18r V₃,

f. 16v B₅

रूपं १ द्वौ २ त्रितयं ३ युगानि ४ च शरास्त्रेधा ५।५।५ रसाः ६
पर्वता ७

भास्वत्केन्द्र।भुजांशदिग्लवकृतं पाते ऽन्यथातिस्फुटः ॥ २ ॥

5

तत्त्वेन्द्रो १४२५ नशकाहता नवभुवो १९ भूबाहव २१ स्त्र्यग्नयो ३३
देवा ३३ स्ते सहिता युगै ४ स्त्रिभि ३ रधो दन्तै ३२ लंवाद्यं तमः ।
सङ्क्रान्त्यर्कनखां २० शकेन गुणभू १३ भागाधिकेनाधिकं
बाणः पातयुतार्कदोर्लवदलं त्रिघ्नं स्वखाग्न्यंश ३० युक् ॥ ३ ॥

Verse 2 1 दिनमणिः] दिनमणे: R₁, दिनमणै: V₅ [भुक्त] भुक्ति R₂R₃ [राश्यादियु] राश्यादिषु R₃
2 क्पर्वान्ते] क्पर्वति V₃ [गति] मति M₁M₂ [दिना] दिनो R₂, दिना marked and the annotation
दिनादिति षष्ठि षटीमिति पूर्वोक्तपलैः गोरामैरित्यादिना उक्तवत्सा^१शं सांशं कुर्यात् added in the margin V₂, दिना
V₅ [दथ] दय R₂R₃V₄ [मयम्] मया V₄ 3 १] om. R₁ [द्वौ] द्वै V₅ २] om. R₁
त्रितयं] द्वितयं R₁ ३] २ M₂, om. R₁ ४] च ४ M₁M₂, om. R₁ [शरा] (श)_{marg,s} रा I, रा रा
V₄ ५।५।५] om. R₁, शरा ५ R₂R₃V₅ [रसाः] रसा M₁R₁ ६] om. R₁, ६।६।६ V₅
4 पर्वता] पर्वता: R₂R₃, corrected from पर्वत to पर्वता V₃ ७] om. R₁ 5 भुजांश] भुजांश B₅
दिग्लव] दिग्ल १० व R₂R₃ [कृतं] मितं B₅R₁V₂V₃ [पाते] पातै B₅, पातं M₁M₂, पोत R₃, पातं पाते
V₄ [ऽन्यथाति] त्वथाति M₁M₂, नयाति R₂, न्ययाति R₃ **Verse 3** 6 १४२५] नं १४२५ शका B₅
नशका] नं शका B₅, न V₄ [नवभुवो] नव[सु]भुवो B₅ १९] १२ B₅, see after देवा in *pāda* b R₁
२१] १२ V₄, see after देवा in *pāda* b R₁ ३३] see after देवा in *pāda* b R₁ 7 ३३] om. IV₂,
देवा १९। २१। ३३। ३३ R₁, देवास्ते ३३ V₅ ४] see end of *pāda* R₁, ४? V₃, om. V₅ ३] see
end of *pāda* R₁, om. V₅ [रधो] रधो IV₂ [दन्तै] corrected from दन्तौ to दन्तै M₂, दन्तै: V₄
३२] om. B₅V₅, see end of *pāda* R₁ [लंवाद्यं] लवाद्यं V₅ [तमः] स्तमः ४।३।३२॥२ R₁ 8 २०]
केन २० B₅V₃, नखांश २० M₁M₂, om. R₁ [शकेन] श[x]केन B₅, शकोन V₅ १३] भागा १३ R₂R₃,
om. V₅ [भागा] नागा M₁M₂V₃ [धिकेनाधिकं] धिवेनाधिकं M₂, धिके(नाधिकं)_{marg} R₂, धिनाधिकं V₅
9 बाणः] बाण[r]: B₅, बाणा: I, नान: M₂ [पात] पात[r] V₂, पात V₃ [युतार्क] युतार्क V₄, युगार्क V₅
दोर्लव] corrected from दोर्लव to दोर्लव V₄ [त्रिघ्नं] त्रि ३ घ्नं R₂R₃ [स्वखा] तु खा IV₄, स्र M₂
खाग्न्यंश] खाग्न्यंश R₁, खां(कां)_{marg}श R₂, खाश R₃ ३०] om. B₅M₁M₂R₂R₃V₃, खाग्न्यंश I, २० R₁

बिम्बं भानोः शर ५ हतगतिः स्वार्क १२ भागोऽनिता स्या -

f. 21r I

दिन्दोर्बिम्बं नवयुगरसा ६४९ स्तारकाभोगभक्ताः ।

त्रि ३ । घ्नं तत्स्यात्सदशमलवं भूमिभा सार्कभुक्तेः

f. 19r R₂

शैलां <७> शोनं युगनग ७४ हतं बिम्बमिन्दोर्गतिः स्यात् ॥ ४ ॥

बिम्बैक्यार्धेषुजकृतिवियोगात्पदं षष्टिनिघ्नं

5

भक्तं भुक्तयोर्विवरकलिकाभिः स्थितेर्नाडिकाः स्युः ।

f. 6r M₁

पर्वान्तस्तद्रहितसहितः स्पर्शमोक्षाख्यकालौ

मानैक्यार्धं शरविःरहितं छन्नमानं वदन्ति ॥ ५ ॥

p. 82 R₁, f. 22v V₄

दर्शान्ते स्वमृणं नतं युग ४ हतं स्वाहर्दलेनाहतं

पश्चात्पूर्वविभागयोरिति मुहुः स्पष्टे त्रिभोनं तनुः ।

10

तत्क्रान्त्यंशपलांशसंस्कृतिलघुज्या ।दि १० ग्विभक्ता स्वया -

f. 17r B₅

धो युक्ता नतिरर्कपर्वणि तया बाणं परिस्कारयेत् ॥ ६ ॥

Verse 4 1 बिम्बं] बिम्ब R₃, बिम्ब V₄ भानोः] भानो R₂V₄ शर] om. R₂R₃ ५] om. B₅M₁M₂R₁R₂R₃V₂V₃V₅ हत] corrected from हत to हत V₂ १२] om. B₅R₁V₃V₅ भागो] भानो R₁ 2 दिन्दो] त् इदो R₁V₂ बिम्बं] बिम्ब R₂, बिम्ब R₃ युग] added in margin I, om. but with an insertion mark though nothing in margin R₁ रसा] रसा: M₁R₁ ६४९] om. V₂V₅ स्तारका] तारका V₄ भोग] भोग्य V₅ 3 ३] om. B₅IM₁M₂R₁V₂V₃V₄V₅ घ्नं] घ्ने R₂R₃ तत्स्यात्स] तस्यरः [त्रि]त्स V₅ दशमलवं] दलशमलं V₅ भूमिभा] marked and the annotation चंद्रबिम्बं त्रिघ्नं दशमांशयुतं रविगतिसप्तमांशोनं भूभा स्यात् written in the margin V₂ भुक्तेः] भुक्तः B₅, भुक्ते R₁, भुक्ते: V₅ 4 शैलां] शैलां R₁V₂ शोनं] शोना B₅IM₁M₂R₂R₃V₃ युग—स्यात्] गृसति शशिनं चंद्रगा हंसमानं R₁, ग्रसति शशिनं चंद्रगा हंसमानं V₂, ग्रसति शशिनं चंद्रमा हंसमानं V₅ युग] यु M₂ ७४] om. B₅M₁R₁R₂R₃V₂V₃V₄V₅, नग I हतं] हतं B₅M₁M₂R₂R₃V₃ बिम्बमिन्दो] बिम्बमिदो R₃, बिम्बमिदो V₄ गतिः] गति(:)supl I, गति M₁ **Verse 5** not numbered I, verse number both after *pāda* c and at the end of the verse V₅ 5 बिम्बै] बिम्बे I षुज] षुज I वियोगा] वियोगा R₂ षष्टिनिघ्नं] पर्वभुक्ता निघ्नं R₁V₂V₅ 6 भुक्तयोर्विवरकलिकाभिः] खयुगयमलै २४० स्यु R₁, खयुगयमलै २४० स्ताः V₂, खयुगयमलै: स्यु V₅ स्थितेर्नाडिकाः स्युः] स्थितेर्नाडिका स्याः B₅, नाडिका स्युः M₁M₂, नाडिकाः स्युः R₃, स्थितैः नाडिकास्ताः V₅ 7 पर्वान्त] पर्वी(त)marg I, पर्वति R₁, प[र]वांत V₄ स्तद्रहित] स्तस्तद्रहित V₄ मोक्षा] मौक्षा B₅ 8 शरवि] विशिख? V₅ छन्न] छन्न B₅, छन V₅ **Verse 6** numbered 60 R₃ 9 दर्शान्ते] दर्शांत R₂, दर्शांत R₃, दर्शांत V₃ स्वमृणं] स्वमृणै R₂R₃ नतं] नभं R₂R₃ ४] om. B₅IM₁M₂R₁V₂V₃V₄ स्वाह] स्वा R₂ 10 मुहुः] कृते R₁V₅ स्पष्टे] स्पष्ट R₁ तनुः] तु तत् B₅M₁M₂R₂R₃V₃, तनु V₄V₅ 11 तत्क्रान्त्यंश] तत्क्रान्त्यंश R₂R₃, क्षत्तांत्यंश V₅ लघु] लघु B₅ १०] B₅IM₁M₂R₁V₂V₃V₄V₅ ग्विभक्ता] ग्विभक्ता M₁M₂ 12 युक्ता] युक्ता R₁ नति] जति R₁ रकं] om. V₅ तया] नया M₁ परिस्कारयेत्] परिकारयेत् R₂R₃

इत्थं श्रीमन्नागनाथात्मजेन
प्रोक्ते तन्त्रे ज्ञानराजेन रम्ये ।

f. 21v I

ग्रन्थागाराधारभूते प्रभूते
युक्त्या युक्ता पर्वसम्भूतिरुक्ता ॥ ७ ॥

f. 18v V₃

Verse 7 1 श्री] added in margin by s R₂, om. R₃ 1-3 मन्नाग—प्रभूते] om. V₂
गनाथा—प्रभूते] om. B₅ नाथा—प्रभूते] om. M₁ 2-3 प्रोक्ते—प्रभूते] om. V₅ 2 प्रोक्ते]
प्रोक्त R₃ रम्ये] म्ये V₄ 3 ग्रन्था] ग्र[र]था V₄ गारा] गा(रा)_{marg,s} R₂, गा[द्यु] R₃
4 युक्ता] युक्त्या M₁V₅, [यु] V₄ **Colophon** इति श्रीसिद्धांतसुंदरे पर्वसंभूतिनामाध्यायः B₅IM₁V₃,
इति श्रीसिद्धांतसुंदरे पर्वसंभूतिनामाध्यायः M₂, om. R₁R₃V₅, इति श्रीनागराजात्मजज्ञानराजविरचिते सिद्धांतसुंदरे
गणिताध्याये पर्वसंभवाधिकारस्तुर्थः in margin by s R₂, इति पर्वसंभूतिनामाध्यायः V₂, इति श्रीमत्सिद्धांतसुंदरे
पर्वसंभूतिनामाध्यायः V₄,

〈अथ ग्रहगणिताध्याये चन्द्रग्रहणाधिकारः〉

ग्रहणकारणतार्कशशाङ्कयो -
 र्वदनपुच्छविभक्तशरीरिणः ।
 |अपम|वृत्तविमण्डलयोगयो -
 निर्वसतस्तमसो मुनिभिः स्मृता ॥ १ ॥

f. 15r R₃, f. 57v V₂

5

श्रुतिपुराणविरोधिजनैः स्मृता
 रविविधुग्रहयोः शशिभूभयोः ।
 करणता क्रमतस्तु न राहुणा
 ग्रहणमित्यपि ते स्वमते जगुः ॥ २ ॥

दशरथात्मजसायकसंहतो
 दशमुखो यदपीति विदो जगुः ।
 दशरथप्रभवेण दशाननो
 हत इहापि पुराणजनस्तथा ॥ ३ ॥

10

chapter opens श्रीलंबोदरो जयति I, श्रीगणेशो जयति V₂ Verse 1 2 ग्रहण] गृहण R₁ 3 र्वदन]
 वदन V₅ पुच्छ] पुच्छ B₅, पूर्व R₂, पु R₃ विभक्त] (वि)_{marg,s}भक्त R₂ शरीरिणः] शरीरिणः
 V₄ 5 निर्वसत] निर्वसत R₃, निर्वस[f]त V₂ मुनिभिः] मुनिभि R₁ स्मृता] स्मृतः I, स्मृताः B₅R₁
 Verse 2 6 श्रुति] स्मृति B₅R₁R₂R₃V₃V₅ जनैः] जनै IR₁ 7 विधु] विधू M₁, शशी V₅
 भयोः] भयो (:) _{supl} R₂, भयो [xxx] R₃, भयो V₃ 8 क्रमतस्तु] क्रमतस्त V₃, क्रमशस्तु V₅ राहुणा]
 राहुणा R₁ 9 ग्रहण] ग्रहण[r] R₃ Verse 3 placed before verse 7 and numbered 6
 B₅M₁M₂R₁R₂R₃V₃V₅ 10 रथात्मज] रथात्मजे V₄ कसंहतो] संहतौ B₅, संहतो M₂ 11 यदपीति]
 यदिपीति B₅V₃, यदिपति M₁M₂, यदिपाति R₁, corrected from य x पीति to यदापीति R₂ जगुः] जनुः
 R₁ 12 दशरथ] दशरथं B₅ प्रभवेण] प्रभवेन B₅IM₁M₂R₁V₂V₃V₄V₅ 13 इहापि] इहापि M₂
 जनस्तथा] विदस्तथा IV₂V₄, विदो जगुः V₅

आच्छादकौ यद्यपि भूप्रभेन्द्र
तथापि राहोरिह कारणत्वम् ।
यतो ऽयमाकृष्य शरेण चन्द्रं
सञ्छादकच्छाद्ययुतिं करोति ॥ ४ ॥

p. 83 R₁

यस्योदिता तैर्विधुपातसञ्ज्ञा
स एव राहुः कथितो महद्भिः ।
तस्याप्यनङ्गीकरणे रवीन्द्रोः
स्यान्मासि मासि ग्रहणं सदैव ॥ ५ ॥

5

f. 22r B₅

पिधानयोग्ये ऽवनिभेन्दुबिम्बे
राहोरिहास्त्रे ग्रहणक्रियायाम् ।
|अतः पुरा|णागमसंहितासु
|नोक्ते तु वेदे किल सूचिते ते ॥ ६ ॥

10

f. 58r V₂, f. 21v V₅

f. 8v M₂

खखेषुष ६५०० ड्योजनसङ्ख्यमैनं
स्याद्विम्बमब्जस्य ख|नागवेदाः ४८० ।
तत्स्पष्टगत्या निहतं विभक्तं
स्वमध्यभुक्त्या स्फुटमानमेवम् ॥ ७ ॥

f. 17v B₅

15

Verse 4 1 आच्छादकौ] आच्छादको M₂V₅ यद्यपि] यद्यपि B₅ प्रभेन्द्र] प्रभेन्द्र M₂, प्रभेन्द्र
R₃V₃ 2 तथापि] तथापि V₃ रिह] रिति R₁ 3 ऽयमाकृष्य] मयाकृष्य M₁M₂ चन्द्रं] चन्द्र V₃
4 सञ्छादक] स छादक M₁M₂ युतिं] युति R₃ Verse 5 placed between verse 2 and
verse 4 and numbered 3 B₅M₁M₂R₁R₂R₃V₃V₅, 5 यस्योदिता तैर्विधु] यस्योदिता तै विधु M₁,
यस्योदितौ तैर्विधु R₁, यस्योदितास्तैर्विधु V₅ पात] ते पा B₅ 6 महद्भिः] मु[र]नीन्द्रैः R₂, मुनीन्द्रैः R₃
7 तस्याप्यनङ्गी] तस्यापि नाङ्गी V₅ करणे] करणो V₅ रवीन्द्रोः] रवीन्द्रोः B₅ 8 न्मासि मासि] न्मासि V₄
सदैव] सदैवा B₅, रविन्द्रोः V₅ Verse 6 placed between after verse 4 and numbered
5 B₅M₁M₂R₁R₂R₃V₃V₅ 9 पिधान] प्रधान R₁, [धा]पिधान V₂ ऽवनि] (ऽ)_{supl}वनि I, सुनि
V₅ भेन्दु] भेद M₁M₂, भेद V₃V₄, भेद V₅ बिम्बे] विव V₃ 10 हास्त्रे] हास्त्रे IM₂R₂V₄,
हास्त्रे? M₁, हास्त्रे? R₁, हास्त्र V₅ ग्रहण] ग्रहण V₅ क्रियायाम्] क्रियायां V₃ 11 णागम] णागुम V₄
12 तु] च B₅M₁M₂R₁R₂R₃V₃, थ V₅ वेदे] वेदा I सूचिते ते] सूचिते ति R₁V₅ Verse 7
13 ६५००] षड्योजन ६५०० B₅M₁M₂V₃, षट् ६५०० योजन IR₂R₃V₂V₄, मैनें ६५०० R₁, षट्योजन ६५०० V₅
मैनं] यैनं R₂R₃ 14 द्विम्बमब्जस्य] द्विबमब्जस्य B₅, द्विबमिन्दोस्तु V₂, द्विबमाज्वस्य V₄ वेदाः] वेदा R₁V₃
15 निहतं] निहितं R₁ 16 भुक्त्या] corrected from भुक्त्य to भुक्त्या I मेवम्] येवम् R₃

इनावनीव्यासवियोगनिघ्नं

शशाङ्कबिम्बं रविबिम्बभक्तम् ।

।फलोन्भूव्याससमा कुभासौ

f. 19r V₃

शरेन्दु १५ भक्ता कलिकादिका स्यात् ॥ ८ ॥

बिम्बोदयप्राणमिति विदित्वा

5

चन्द्रार्कयोर्मध्यगतौ तथा घ्नी ।

कक्षा दुरात्रासुहृता स्वबिम्बे

स्युर्योजनानीत्यनुपातयुक्त्या ॥ ९ ॥

f. 20r R₂

या सूर्यनिर्गतमरीचिकुपृष्ठयोगा -

f. 23v V₄

त्सूचीसमा भवति भा ख इनाद्दषद्वे ।

10

तद्विस्तृतेः परिमितिर्विधुकक्षिकायां

दीपप्रभागणितवद्विबुधैः प्रसाध्या ॥ १० ॥

p. 84 R₁, f. 15v R₃,

f. 58v V₂

Verse 8 2 शशाङ्क] शशाक V₃, शशाकं V₅ बिम्बं] विंब R₃ बिम्ब] स्व V₄ भक्तम्] भक्तां V₅ 3 फलोन्भू] फलोन्भू R₃, फलेन V₅ कुभासौ] बुभासौ R₁, हिमांशो (:) ^{supl} V₂ 4 शरेन्दु] शारेन्दु V₃ १५] om. B₅M₁M₂R₁V₃V₅ कलिकादिका] कलिकादि (का) ^{supl} B₅, कलिका (दिका) ^{marg,s} R₂ **Verse 8** 5 बिम्बो] marked and the annotation अत्रोपपत्तिः added in margin by s R₂ मिति] मिति R₃ 6 चन्द्रार्कयो] चं के द्रा यो M₁, चन्द्रादयो V₅ गतौ] गती R₁ तथा] तपो R₁, फल V₅ 7 द्यु] द्य R₃ रात्रासु] रात्रे स्व V₅ स्वबिम्बे] स्वविंब M₁M₂, सुविंबे R₂ **Verse 10** 9 या सूर्य] marked and the annotation भूभाविंबोपपत्तिः added in margin by s R₂ मरीचि] मरिचि V₄ 10 त्सूची] त्सूचा R₁, सूची V₅ भा ख इनाद्दषद्वे] ख इनाद्दषद्वे B₅, रविसो भषद्वे V₅ 11 तद्विस्तृतेः] तद्विस्तृतेः B₅M₂V₅, तत्संमितेः IV₂, तद्विस्तृतेः M₁, तत्संमितेः V₄ विंधु] विं B₅ कक्षिकायां] कक्षिकायां B₅V₂V₃V₅, क (f)क्षिकायां I, काक्षिकायां M₂, कछकायां R₁, कक्षकाया V₄ 12 दीपप्रभा] दी प्रे प भा M₁ गणितवद्वि] गणिवद्वि B₅, गणितवद्वि R₂R₃ बुधैः] बुधै R₁ प्रसाध्या] प्रसाध्या R₁V₄V₅

इना|वनीव्यासदलान्तरं चे -
 त्कोटिर्दिनेशश्रुतितुल्यभायाः ।
 तदेन्दुमध्यश्रवणप्रमाण -
 च्छायाभुजे केति फलं भवेद्यत् ॥ ११ ॥

f. 22v I

तच्चन्द्रदेशे ऽवनिभाप्रमोत्थ -
 व्यासार्धहीनार्धकुविस्तृतिः स्यात् ।
 इत्यत्र कर्णावपवर्त्य जाता -
 वङ्केन बिम्बे गुणभागहारौ ॥ १२ ॥

5

तिथ्यन्तनाडीहतबहुक्तिलिप्ताः
 पूर्णाङ्ग ६० भक्ताः स्वफलेन हीनः ।
 राहुः शशी तौ ^(a) सहितौ भवेतां
 तिथ्यन्तकाले समलिप्तिकौ तौ ॥ १३ ॥

10

Verse 11 1 दलान्तरं] दलन्तरं V₄ 2 त्कोटिर्दिने] त्कोटि[?]दिने V₅ श्रुति] श्रुति B₅R₁V₃
 तुल्य] तुल्य[र] V₄ भायाः] भायां R₂ 3 तदेन्दु] तदिदं R₁, [भाप्रमोत्थव्यासाद्ध] तदेदं V₃, त[र]देदं V₄
 प्रमाण] प्रमाणं R₁ 4 भुजे] भुजैः V₄ फलं भवेद्यत्] corrected from फलं भवेद्यत् to फलं भवेद्यत् B₅,
 भवेत्कलं यत् R₁ **Verse 12** 5 देशे] दोशे M₁, दोंशे M₂ प्रमोत्थ] प्रमोत्थ R₁, प्रमाण with माण
 marked and the variant reading मोत्थ noted in margin by s R₂, प्रमोत्थ V₂, डाभोत्थ V₄, प्रयोछ[?] V₅
 6 व्यासार्ध] व्यासाद्ध V₃ विस्तृतिः] विस्तृ[?]तिः B₅, विस्मृतिः M₁ 7 कर्णाव] कर्णोओव B₅I पवर्त्य]
 पवर्त्य M₁M₂, यवर्त्य R₁ 8 वङ्केन] वक्केन V₄ **Verse 13** 9 तिथ्यन्त] तिथ्यन्तं V₃, तिथ्यान्त V₅
 हुक्ति] corrected from भुक्त to भुक्ति V₃ लिप्ताः] लिप्ता IR₁V₂V₄ 10 पूर्णाङ्ग] पूर्णैंग R₂, पूर्णैंग R₃,
 पूर्णाङ्गा V₄ ६०] om. B₅M₁M₂V₅ भक्ताः] भक्ता IV₂V₄ स्व] स[?] I 11 शशी] शी V₄ तौ]
 नौ all mss. 12 तिथ्यन्त] corrected from तिथन्त to तिथ्यन्त R₂, (ती)_{marg}थ्यन्त V₃ काले] कालः V₅
 लिप्तिकौ] लिप्तिकौ R₁

(a). Although all available manuscripts have शशीनौ, a better reading is शशी तौ, as given in the text.

स्वर्भानूनितशुभ्रभानुजभुजाज्जीवाभ्रतारा २७० हता
 त्रिज्याप्ता शशिसायकः स वितमः शीतांशुगोलोत्थदिक् ।
 ग्राह्यग्राहकमानसंयुतिदलं स्यात्सायकेनोनितं
 छन्नं ग्राह्यविहीनमेतदुदितं खग्राससंज्ञं बुधैः ॥ १४ ॥

f. 18r B₅, f. 59r V₂

बिम्बयोगदलबाणवर्गयो -

5

रन्तरालपदमभ्रष ६० ङुणम् ।

अर्कचन्द्रगतिभाजितं भवे -

f. 24r V₄, p. 85 R₁,

f. 19v B₅

चन्द्रपर्वणि फलं स्थितेर्दलम् ॥ १५ ॥

f. 20v R₂

मानखण्डविवरार्धमर्दकं

f. 23r I

तद्वदेव भवतीह मध्यमम् ।

10

स्पर्शमोक्षसमयोत्थसायका -

त्साधितं स्थितिदलं स्फुटं निजम् ॥ १६ ॥

Verse 14 1 स्वर्भानूनित] स्वभ्रानूनित M₁M₂, corrected from स्वर्भानूनित to स्वर्भानूनित V₃, स्वर्भानूनित V₅ भानुजभुजाज्जीवा] भानुजभुजा जीवा IV₂, भानुजभुजा जीवा R₂V₅, भानुजभुजा जीवा V₄ २७०] om. B₅M₁M₂V₃V₅ 2 सायकः स वितमः] सायकःस्त्वभिमतः V₅ सायकः स] सायकस्तु IV₂V₄ वितमः] corrected from वितमुः to वितमः V₄ शीतांशु] शीतांश M₁ दिक्] दिक् V₃ 3 ग्राह्य] ग्राह्यं M₁M₂ संयुति] योगज V₅ स्यात्सायके] स्यान्नायके V₄ नोनितं] नोनित R₁, नूनितं R₂R₃ 4 छन्नं] छन्नं M₂, छन्नं V₅ ग्राह्य] गृह्य V₄ विहीन] वि [f]ह (r)न V₃ मेतदुदितं] मेत उदितः B₅, मेत उदितः M₁, मेतदुदितः M₂R₁V₃, मेतदुदितः V₄, यैतदुदितः V₅ खग्राससंज्ञं] खग्राससंज्ञो B₅IM₁M₂R₁V₃V₅, ससं ज्ञं V₄

Verse 15 not numbered V₄ 5 बाण] बाल B₅ 6 पद] marked and the annotation त्रिभ्रं added in margin V₂ मभ्र] मभ्र R₁, मभ्र V₄ षड्गुणम्] यद्गुणं V₄, षे²रुणं V₅ ६०] om.

B₅IM₁M₂R₁V₃V₄V₅, षड्गु ६० णं R₂R₃, षषड्गुणं V₂ 8 चन्द्र] चन्द्र B₅, चन्द्र V₅ पर्वणि] पर्व V₄ फलं] फल M₂R₁ स्थितेर्दलम्] om. due to confusion with end of next verse V₄ **Verse 16**

9-12 मान—त्साधितं] om. due to confusion with end of last verse V₄ 9 विवरार्धमर्दकं] विवरार्धमर्दकं B₅I, same with विवरा marked and the gloss वर्गात् added in margin by s and द्विमर्दकं marked and the annotation मानार्द्धविवरवर्गं [स्पर्श] मर्दबाणवर्गयो रन्तरालपदं षष्टिभ्रं । रविचन्द्रांतरगतिभक्तं स्पर्शमर्दकं स्यात् एवं मोक्षमर्दः added in margin by s V₂ 10 भवतीह] भवती M₁ मध्यमम्] मध्यकं B₅V₃ 11 समयोत्थ] समयो (त्थ)_{margin} I 11-12 सायकात्साधितं नाडिकात्साधितं I, सायकात्साधितं M₁, सायका साधिता R₂, सायका साधिते R₃ 12 दलं] दल R₁ स्फुटं निजम्] स्फुटं निशि R₁, निजं स्फुटं R₂R₃

तिथ्यन्तकाले स्थितिहीनयुक्ते
 स्पर्शाख्यमोक्षौ भवतः क्रमेण ।
 एवं विमर्दार्धविहीनयुक्ते
 सम्मीलनोन्मीलनसञ्ज्ञकालौ ॥ १७ ॥

f. 22r V₅

भूभाकेन्द्रं क्रान्तिवृत्ते तथेन्दोः
 केन्द्रं बाणाग्रे ऽथ तत्क्षेपवृत्ते ।
 स्पर्शे मानैक्यार्धतुल्यान्तरे ते
 मध्यग्रासे बाणतुल्यान्तरे स्तः ॥ १८ ॥

5

तस्मान्मानैक्यार्धतुल्यो ऽत्र कर्णः
 कोटिर्बाणो वर्गविश्लेषमूलम् ।
 दोः स्यात्स्थित्यर्धं तदेवानुपाता-
 न्नाडीरूपं व्यर्कचन्द्रस्य मार्गे ॥ १९ ॥

10 f. 16r R₃

f. 59v V₂

Verse 17 2 स्पर्शाख्य] स्पर्शा[x](ख्य)_{marg,s} R₂, स्पर्शाख्य V₃, स्पर्शाख्य[r] V₄, स्पर्शाक्ष V₅
 4 सम्मीलनो] सन्मीलनो B₅R₁V₃V₅, संमीनलनो I, सम्मीलनो M₁ सञ्ज्ञ] सञ्ज्ञ V₅ **Verse 18**
 5 भूभा] marked and the annotation अत्रोपपत्तिः added in margin by s R₂, damaged due to tear
 in ms. V₅ केन्द्रं] केन्द्रे R₁V₅ तथेन्दोः] (त)_{supl}थेन्दोः B₅, तथे'दोः M₁ 6 केन्द्रं] केन्द्रे R₁ बाणाग्रे
 ऽथ] बाणग्रं थ V₅ तत्क्षेपवृत्ते] तत्क्षेपवृत्तेः B₅, corrected from तक्षेपवृत्ते to तत्क्षेपवृत्ते I, तत्क्षेपवृत्तेः M₁,
 तत्क्षेपवृत्तं R₁, तत्क्षेपयुक्ते with तत्क्षेप marked and the gloss चंद्रशर added in margin by s R₂, तत्क्षेमयुक्ते
 R₃, तक्षेपवृत्ते V₃, तत्क्षेवृत्ते V₄ 7 स्पर्शे मानै] स्पर्शेर्मा V₅ तुल्यान्तरे ते] तुल्ये'तरे ते R₁, corrected from
 तुल्यंतरे ते to तुल्यांतरे ते R₂, तुल्यांतराले V₂V₄ 8 ग्रासे] ग्रासौ R₁ बाणतुल्यान्तरे] बालतुल्यांतरे V₃
Verse 19 9 न्मानै] न्मौनै M₁ ऽत्र] कं M₁M₂V₃ 10 बाणो] बाणौ M₁M₂R₃, corrected
 from बाणौ to बाणो R₁ 11 दोः] दोः(_{supl}) I स्यात्स्थित्यर्धं] स्यात्स्थित्यर्धं V₄, स्या स्थित्यर्धं V₅
 11-12 पातान्नाडी] पातां नाडी M₁ 12 रूपं] रूपं V₃ चन्द्रस्य] corrected from चंद्रस्य to चंद्रस्य R₁

स्पर्शाद्विमुक्तेरथ वेष्टकाले
चेत्साध्यते ग्रासमितिस्तदानीम् ।
निजस्थितीष्टान्तरनाडिकाघ्नी
व्यर्केन्दुभुक्तिः खरसै <६०> विभक्ता ॥ २० ।

फलं भुजस्तत्समयोत्थबाणः
।कोटिः श्रुतिस्तत्कृतियोगमूलम् ।
कर्णोन्मानैक्यदलप्रमाण -
मुद्दिष्टकाले स्थगितं विचिन्त्यम् ॥ २१ ॥

।पूर्वापरा या स्ववशेन बिम्बे
तन्निष्ठपूर्वग्रहमध्यमोक्षैः ।
प्रयोजनं द्रष्टुरतो ऽथ तेषां
दिक्साधना।र्थं वलनानि वक्ष्ये ॥ २२ ॥

एकमक्षवशतो वलनं स्या -
द्यद्वितीयमयनद्वयजातम् ।
इन्दुबाणवशतश्च तृतीयं
सूर्यपर्वणि तु यन्नतिसञ्ज्ञम् ॥ २३ ॥

Verse 20 1 स्पर्शा] पशां M₂, स्पर्श V₄ 3 निज] निजे V₃ स्थिती] स्थिती[भ्यां] M₁, स्थि[ति]ती V₂, स्थिति V₅ नाडिका] नाडीका B₅V₄ घ्नी] घ्नी V₅ 4 व्यर्केन्दु] व्यर्केन्दु V₃ भुक्तिः] भुक्तैः V₅ विभक्ता] विभक्ताः R₁ **Verse 21** 5 स्तत्समयोत्थ] स्तत्समयोत्थ M₁, स्तमयोत्थ M₂ 6 कोटिः] कोटि B₅M₂ श्रुति] श्रुति R₁ योग] योम V₄ 8 मुद्दिष्ट] मुदिष्ट V₃ स्थगितं विचिन्त्यम्] स्थगतिविचिन्त्या R₁ स्थगितं] स्वगितं I, स्थगितं M₂, स्थगित V₃, स्थगितं V₄, स्थगितं V₅ **Verse 22** 9 पूर्वापरा] पूर्वोपरा V₄ या] या(:)supl R₂, याः R₃V₄ बिम्बे] बिम्ब V₄V₅ 10 तन्निष्ठ] तन्मिष्ट R₂R₃, तेन्निष्ठ V₄ मोक्षैः] पक्षौ V₅ 11 द्रष्टुरतो] द्रष्टुनतो V₅ 12 वलनानि] वलनादि R₂R₃V₅ **Verse 23** 13 एकमक्ष] एवमक्ष R₁ 14 द्यद्वि] द्यद्वि B₅IM₁M₂R₁V₂V₄V₅ मयन] मयन V₅ 15 इन्दु] इन्दु V₅ वशतश्च] वशतस्तु V₅ 16 सूर्य] सूर्य[व] B₅ तु] om. M₂, च V₃ यन्नति] यां नति M₂, यन्नति V₅

पूर्वापरा यापमवृत्तगत्या

f. 60r V₂

सञ्छादको यन्ननयैव^(a) बिम्बम् ।

f. 20r V₃

शून्ये शरे छादयतीत्यतो य-

तत्स्वीयपूर्वापररेखयोः स्यात् ॥ २४ ॥

मध्ये ऽन्तरं तद्वलनं ग्रहस्य

5

स्पष्टं मयेति प्रकटं प्रदिष्टम् ।

बाणोदये तद्वलनाग्रतस्तं

दत्वा वदेत्स्पर्शविमोक्षकाष्ठाम् ॥ २५ ॥

सायनांशखचरात्तिभाधिका-

f. 24r I

द्वोर्ज्यका जिनलवज्ययाहता ।

10

भाजिता त्रिभगुणेन तद्धनुः

सत्रिराशिखगदिक्तदायनम् ॥ २६ ॥

Verse 24 1 परा यापम] परा या (ऽ)^{supl}पम I, परा यायम M₁M₂, परा या मे^३प^१ R₃, परायामप V₂V₄V₅
वृत्त] पूर्व B₅V₃, वृत्ति M₁M₂, वृत्त्य V₅ 2 सञ्छादको] संस्छादको V₅ यन्ननयैव] यन्नयनैव B₅V₅, यं
नयनैव M₁M₂, यन्ननयैव V₄ बिम्बम्] विवम् V₄ 3 शून्ये] शून्य R₁ शरे] छरे M₂ छादयतीत्यतो]
छादयतीततो R₁, छादयतीततो V₅ 3-4 यत्तत्स्वीय] यतत्स्वीय M₁M₂V₄, यन्न^२त्स्वीय V₅ 4 रेखयोः]
रेखयो M₁V₃V₅ **Verse 25** 5 मध्ये ऽन्तरं] मध्ये नारं V₄ ग्रहस्य] ग्रहास्य R₁ 6 स्पष्टं] स्पटं
M₁M₂ 7-8 तद्वलनाग्रतस्तं दत्वा] तद्वलनाच्छरं तं दत्वा IV₂, तद्वलनाग्रतस्तं दत्वा V₄, तद्वलनाग्रतस्तदत्वा V₅
8 त्स्पर्श] त्स्पर्श M₁ विमोक्ष] विमुक्ति R₂, विमुक्ति with मुक्ति marked and the variant reading मोक्ष
added in the margin R₃ काष्ठाम्] काष्टं R₃V₅ **Verse 26** 9 चरात्ति] चरा त्रि IM₁V₄V₅
9-10 भाधिकाद्वोर्ज्यका] साधिकाद्वोर्ज्यका R₃, भाधिका दोर्ज्यका R₂V₅ 10 जिन] जि x (न)^{supl} B₅ लव]
लवा M₁ ज्यया] ज्यका R₁R₂R₃V₅ हता] हताः R₂ 11 त्रिभ] त्रि(भ)^{marg,s} R₂ गुणेन]
after गुणेन is about 8 erased akṣaras R₂, गुणेन ता भाजिता त्रिभगुणेव R₃ 12 खग] खलु M₁M₂, खल
V₃, ग्रह V₄ दिक्तदायनम्] दिक्तदायने M₂, दृक्तदायनम् V₄

(a). This phrase appears to be corrupt.

नतगुणाभिहता पलकर्णह -
द्विषुवती फलचापलवोन्मितम् ।
पलभवं वलनं तदिदं भवे -
चलनमक्षवशादयनोद्भवे ॥ २७ ॥

f. 6v M₁

समविभिन्नदिशोर्युतिरन्तरं
वलनयोरवशेषगुणो हतः ।
त्रिभगुणेन हतो निजमानयो -
र्युतिदलेन भवेद्वलनं स्फुटम् ॥ २८ ॥

5

p. 87 R₁

याम्योदग्वलये ऽयनादिगखगं बोधाय कल्प्यात्र या

f. 16v R₃, f. 60v V₂,

f. 25r V₄

बिम्बप्रागपरापमण्डलपथात्स्यात्सैव पूर्वापरा ।
व्यक्षे ऽतो ऽयनसन्धिगे न वलनं खेटे तुलाजादिगे
तत्पूर्वापररेखयोस्तु परमक्रान्त्यंशतुल्यान्तरम् ॥ २९ ॥

10

f. 21r R₂

Verse 27 1-2 नत—विषुवती] marked and annotation नतं ष^२ङ्कु^२णं अंशास्तेषां ज्या तयाभिहता अक्षभा
added in the margin V₂ 1 नतगुणा] न^२गुण V₄ कर्ण] कर्ण [r] M₁ 2 द्विषुवती] द्विषुवत्तां R₁
फलचापलवोन्मितम्] फलवोन्मितान् V₄ 3 पल] फल R₁, corrected from पले to पल V₃ भवं]
भव R₃ 4 चलनमक्षवशादयनोद्भवे] चलनमक्षवशाद्वलने यने I, दलनमक्षवशादयनोद्भवे R₂, दलनमक्षवशादयनोद्भवे
R₃, चलनमक्ष[मक्ष]वशाद्वलने यने V₂, चलनमक्षवशाद्वलने ऽयनम् V₄, वलनमक्षवशादयनोद्भवे V₅ **Verse 28**
5 दिशोर्युतिरन्तरं] दिशो युतिरन्तरं B₅R₂R₃, दिशोर्युतिमन्तरं M₁M₂R₁V₃, corrected from दिशोर्यविरन्तरं to
दिशोर्यविरन्तरं V₄ 6 योरव] यो [x] रव B₅ शेष] शेष R₁ 7 त्रिभ] त्रिभु B₅V₄ गुणे] गुणे [f] न V₃
हतो] हतो R₁V₄ निज] नित M₁M₂V₃ 8 दलेन] भवेन M₂ भवेद्वलनं] दलेद्वलनं M₂, दलनं [योरव]
स्फुटं V₃ **Verse 29** 9 ग्वलये] ग्वलयं R₂ कल्प्यात्र] कल्पात्र R₁, कल्प्याऽत्र V₄, कल्पा^२त्र V₅
10 बिम्ब] बिंबे V₅ मण्डल] मंडल I पथात्स्यात्सैव] पथा स्यात्सैव IV₂, स्यात्सेव M₁, corrected from
त्स्यात्सेवे to तस्यात्सेव M₂, यथा स्यात्सैव R₁, [त]स्यात्सैव R₂, तस्यात्सेव V₄ 11 ऽतो] ता R₁ वलनं] ललवं
V₅ खेटे] खे [x] टे V₂ तुलाजादिगे] तुलालादिगे I 12 तत्पूर्वा] तत्^२र्वा V₄ योस्तु] योश्च IV₂V₄
परम] पर B₅ तुल्यान्तरम्] तुल्यीतरम् V₄

अवान्तरस्थे खचरे ऽनुपाता -
 तदायनं । स्याद्वलनं निरक्षे ।
 साक्षे ऽक्षतस्तच्चलतीति पूर्वैः
 पलोद्भवं तद्वलनं प्रयुक्तम् ॥ ३० ॥

f. 19r B₅

कल्प्यापवृत्तं सममण्डलाभं
 याम्योत्तरस्वक्षितिजे ततो ये ।
 तद्योगतस्तत्क्षिति जावधिः स्या -
 तदायनाख्यं वलनं स्वदिक्कम् ॥ ३१ ॥

5

f. 22v V₅

याम्योदग्वलयस्थिते दिविचरे या बिम्बपूर्वापरा
 व्यक्षे सैव निजात एव वलनं नोत्पद्यते ऽत्राक्षजम् ।
 स्वक्षमाजे तु तदन्तरं पलगुणो मध्ये ऽनुपातेन य -
 तत्प्रोक्तं वलनं बुधैः पलभवं तेनायनं संस्कृतम् ॥ ३२ ॥

f. 20v V₃

10

Verse 30 1 अवान्तर] corrected from अवांतरे to अवांतर I स्थे] corrected from स्थै to स्थे V₄ खचरे] ख(च)_{marg,s} रे R₂ ऽनुपाता] (नु)पाता B₅, नुपात्ता V₄ 2 द्वलनं] द्वलना R₁
 3 साक्षे] सापे R₁ ऽक्षतस्त] पतस्त B₅M₁M₂, यतस्त R₂R₃V₃, क्षजात V₅ पूर्वैः] पूर्वै R₁V₃V₅,
 पूर्वै R₃ 4 पलो] पर्ला V₄ तद्वलनं] corrected from तद्वलनं to तद्वलनं V₄ प्रयुक्तम्] स्वदिक्तं
 M₂ **Verse 31** 5 कल्प्या] कल्पा V₅ मण्डलाभं] मंडलाभ्यां V₅ 6 याम्योत्तरं] याम्योत्तरं
 I, याम्योत्तरे R₂R₃V₅ स्वक्षितिजे] (स्व)_{marg,s} R₂ ततो ये] तयोर्ये I, नतो ये M₂, ततो जे V₅
 7 तद्योग] तस्तत्क्षिति] तद्योगतस्त क्षिति B₅, तद्योगतः स्वक्षिति IV₄V₅, तद्योगतः स्वक्षि(f)ती I, तद्योगत स्वक्षिति
 V₃ जावधि:] जावधि M₁M₂R₁R₂R₃V₃ 8 नाख्यं] ना(ख्यं B₅, नाख्यं[r] V₄ वलनं] लवनं V₄
 स्वदिक्कम्] स्वदिक्तं M₁M₂, स्वदिक्कमु V₄, xx द्रवं V₅ **Verse 32** both first and second half
 of the verse numbered 32 R₁ 9 याम्योद] याम्यो(द)_{marg} I, याम्यो[f]द M₁, marked and
 the annotation अत्रोपपत्तिः added in the margin by s R₂ ग्वलय] ग्वलये V₅ या] य V₅
 10 व्यक्षे सैव निजा] व्यक्षां[?]शैर्वनिजे V₅ त एव] (ऽ)_{supl}त एव R₂ वलनं] लनं V₃ नोत्पद्यते]
 corrected from नोत्पद्यते to नोत्पद्यते V₃, नोत्पन्न V₅ 11-12 दन्तरं—संस्कृतम्] om. but added in
 margin दन्तरं पलगुणो मध्ये नुपातेन यत् प्रोक्तं वलनं बुधैः पलभवं तेनायनं संस्कृतं by s V₃ 11 दन्तरं] दंतरो R₁
 12 वलनं] वल V₄ बुधैः] बुधै R₁

परितो ग्राह्यकेन्द्राद्य -
 न्मानै|क्यार्धेन मण्डलम् ।
 द्रष्टुग्राहककेन्द्रस्पृ -
 कसूत्रसक्तं तदा ग्रहः ॥ ३३ ॥

p. 88 R₁

स्पर्शदिङ्को विलोमेन
 दत्त्वा शरमिताङ्गुलम् ।
 ततो बिम्बगपूर्वाशा -
 पर्यन्तं व|लनं स्फुटम् ॥ ३४ ॥

5

f. 25v V₄

पर्वान्तः किल साधितो भवलये सूर्येन्दुचिह्नान्तरा -
 तस्मिन्बिम्बसमागमो न हि यतश्चन्द्रः शराग्रे स्थितः ।
 तस्मादायनदृष्टिसंस्कृतवि|धोरानीततिथ्यन्तके
 बिम्बैक्यं भवतीति किं न विहितं पूर्वैर्न विप्रो वयम् ॥ ३५ ॥

10

f. 25r I

Verse 33 numbered 32 V₂ 1 ग्राह्य] corrected from ग्रह्य to ग्राह्य I केन्द्राद्य] केन्द्रा
 य B₅, केन्द्रा [x]द्य I, केन्द्राद्य [r] V₄, केन्द्रा x V₅ 2 न्मानै] न्मा (नै)_{marg} I, न्माने M₁, corrected
 from न्मानै to न्माने M₂, x नै V₅ क्यार्धेन] क्यार्द्धेन V₄ 3 ग्राहक] corrected from ग्रहिक to
 ग्राहक I, ग्रहक V₅ केन्द्र] केद्र R₁, कन्द्र V₄ 3-4 स्पृक्सूत्र] corrected from स्पृक्सूत्रं to स्पृक्सूत्र
 R₂, स्य सूत्रं V₅ 4 तदा] त²दा with त added in the margin to make the reading clear V₂
Verse 34 numbered 33 V₂ 5 स्पर्श] स्पर्शा M₁M₂R₁, स्पर्श [r] V₂ दिङ्को] दिक्तो IV₂V₄,
 दिङ्के² V₅ 7 ततो] xx V₅ बिम्बग] बि [x](ब)_{marg,s}ग R₂, बिबाग V₂V₄ पूर्वाशा] पूर्वाश
 R₁ **Verse 35** numbered 34 V₂ 9 पर्वान्तः] पर्वान्तः B₅V₅ साधितो] साधिते R₁
 भवलये] glossed as क्रांतिवलये in the margin by s V₂ सूर्येन्दु] सूर्येन्दु V₅ चिह्नान्तरा] चिह्नान्तरा V₃
 10 तस्मि] तस्मि V₅ समागमो] समागमौ M₂V₅ शराग्रे] शरोग्रे B₅ 11 संस्कृत] संस्कृत V₃
 रानीत] रानीन V₅ तिथ्यन्तके] तिथ्यं ततो M₁M₂ 12 बिम्बैक्यं] बिम्बैक्य M₂ भवतीति] भवतिति R₃
 किं न] किन्न R₁, किन्न V₅ विहितं पूर्वैर्न] विहिते²पूर्वैर्न B₅, विहितं पूर्वैर्न IV₃ विप्रो] विप्रो V₅

दोज्या सत्रिभसायनांशकविधोर्लघ्वी त्रिचन्द्रा १३ हता
 दन्ताप्ता ३२ सापमसिञ्जिनीह निहता बाणेन सा त्रिज्यया ।
 भक्ता लब्धकला विधौ धनमृणं भिन्नैकदित्के शर-
 क्रान्त्योरायनदृष्टिकर्मविहिताच्चन्द्रात्तिथिः पर्वणि ॥ ३६ ॥

f. 17r R₃

ग्राहस्य केन्द्रात्परितः प्रकल्प्य
 मानार्धयोगाङ्गुलसूत्रवृत्तम् ।
 दिक्साधने ऽस्मिन्वलयनं प्रदेयं
 यथादिशं स्पर्शभवं विधोः प्राक् ॥ ३७ ॥

5

f. 61v V₂

तन्मौक्षिकं पश्चिमतः खरांशो-
 व्यस्तं ज्यकावच्च शरौ तदग्रात् ।
 रेखा सुदीर्घा वलनाग्रयोर्या
 तिर्यक्च रेखात्र तु मध्यबाणः ॥ ३८ ॥

10 f. 19v B₅

p. 89 R₁

Verse 36 numbered 35 V₂ 1 दोज्या] सेज्या R₁ विधोर्लघ्वी] विधोर्लघ्वी R₁, विधौ लब्ध V₅
 त्रिचन्द्रा] विचन्द्रा R₂R₃ १३] om. B₅IM₁M₂R₁V₂V₃V₄, placed at the end of the *pāda* V₅
 हता] corrected from हतां to हता V₄, हतं V₅ 2 दन्ता] दन्ताप्ता I ३२] om. IR₁R₂, दन्ताप्ता ३२ M₂
 निहता] तिहता V₅ बाणेन] बाणोन M₂ सा] स B₅ 3 भक्ता] भक्त्या V₅ धनमृणं] धनमृण V₃
 दित्के] दित्के? B₅ शर] शरे V₃, सर V₅ 4 क्रान्त्यो] क्रान्त्या R₁, क्रान्त्यो V₅ विहिता] विहता B₅,
 corrected from किहिता to विहिता V₄ चन्द्रात्तिथिः] चन्द्रा तिथिः M₂R₂, चन्द्रा तिथिः V₅ **Verse 37**
 numbered 36 V₂ 5 केन्द्रा] केद्रा V₃ प्रकल्प्य] प्रकल्प्यं IR₂, प्रकल्प R₁V₅, प्रकल्प्या R₃ 7 दिक्साधने
 ऽस्मिन्वलयनं] दिक्साधिते स्मिन्वलयनं IV₂V₄, दिक्साधनार्थं वलयनं M₁M₂, दिक्साधने स्मिन्वलयनं V₃ प्रदेयं] प्रदेशं B₅
 8 यथादिशं] यथादिशं M₂, यथादिशं V₄ विधोः] विधी V₃ **Verse 38** numbered 37 V₂,
 not numbered V₅ 9 तन्मौक्षिकं] तन्मौक्षिकं V₄ पश्चिमतः] पश्चितः M₁ खरांशो] खरांशौ M₂
 10 व्यस्तं] व्यस्त M₁, व्यस्त M₂, व्यस्त R₁, वस्त V₅ ज्यका] चका M₂ शरौ] शरौ V₄ तदग्रात्]
 तदायत् R₁ 11 रेखा] रेखा V₄ सुदीर्घा] समुत्था V₂, समुत्था V₄ 11-12 वलना—बाणः] om.
 V₅ 11 वलनाग्रयोर्या] वलनाग्रयोर्या B₅, वलनायोर्या V₄ 12 तिर्यक्च] तिर्य्यं (क्) marg,s कु R₂, तिर्य्यं कु R₃
 बाणः] बाण [r]म् V₄

केन्द्राद्यथादिक्शरचिह्नकेषु

यथा भवेद्ग्राहकबिम्बकेन्द्रम् ।

स्पर्शे ऽथ मध्यग्रहणे च मोक्षे

तथा तथा दिङ्मो यमो विचिन्त्यः ॥ ३९ ॥

f. 25v I

f. 21r V₃

। इत्थं श्रीमन्नागनाथात्मजेन

प्रोक्ते तन्त्रे ज्ञानराजेन रम्ये ।

ग्रन्थागाराधारभूते प्रभूते

सम्पूर्णो ऽयं चन्द्रपर्वाधिकारः । ॥ ४२ ॥

5 f. 26r g V₄

f. 62r V₂

Verse 39 numbered 38 V₂V₅ 1-3 केन्द्रा-च] om. V₄ केन्द्रा-मध्य] om. V₅
1 केन्द्रा] केंद्र M₂, केद्रा V₃ दिक्शर] शे रे दि के M₁, दिक्सर R₁, दिक्श [f]r V₃ 3 स्पर्शे] स्पर्शो IV₂
मध्य] मध्ये M₁M₂ ग्रहणे] ग्रहणं IV₂ मोक्षे] मोक्ष IM₁M₂V₂V₄ 4 तथा तथा] स्तथा तथा
IV₂, तथा (तथा)_{marg} R₃, स्तथा V₄ दिङ्मो यमो विचिन्त्यः दिङ्मोयेन चिन्त्यं IV₂, दिङ्मोयेन चिन्त्यम् V₄
after the verse are two additional verses चंद्रोपरगा न्यदिशः शराः स्युः स्पर्शान्त्यबाणाग्र | (f. 26r V₄) गते
ऽथ सूत्रे । आमध्यबाणं परिलिख्य केंद्राद्विबांतरार्धेन विधाय वृत्तं ॥ (with दिशः and स्युः in *pāda* a I, बाणागते for
बाणाग्रगते in *pāda* b V₄, तरा [xx] देन I) and तद्बाणसूत्रद्वयसंयुतिभ्यां वृत्तद्वयं ग्राहकखंडेन । तद्बाह्यबिम्बेन समन्वितं
स्यात्सम्मीलनोन्मीलनमत्र चिन्त्यं ॥) with स [स] मन्वितं in *pāda* c V₄) IV₂V₄ (the first numbered 40 I, 39
V₂V₄, and the second numbered 41 IV₄, 40 V₂) **Verse 40** not numbered IR₂R₃V₂
5 श्रीम] श्रीग[?]ग B₅ 5-7 गनाथा—प्रभूते] om. B₅ 5 जेन] जेनः V₃ 6-7 प्रोक्ते—प्रभूते]
om. M₁M₂V₃V₅ 6 तन्त्रे] तत्रे V₄ रम्ये] रम्ये R₃ 8 सम्पूर्णो] संज्ञातो IV₂, संज्ञातो V₄
चन्द्र] om. M₂, corrected from चन्द्र to चन्द्र V₄ कारः] कारः ५ V₄ **Colophon** on
ff. 43r-43v V₁ इति सिद्धांतसुंदरे चंद्रग्रहणाधिकारः B₅, इति सकलसिद्धांतवासनाविचारचतुरचित्तचमत्कारकारिणि
सिद्धांतसुंदरे चंद्रग्रहणाधिकारः I, इति श्रीसिद्धांतसुंदरे चंद्रग्रहणाधिकारः M₁, इति श्री सिद्धांतसुंदरे चंद्रग्रहणाधिकारः
M₂, no colophon R₁, इति श्रीनागराजात्मजज्ञानराजविरचिते सिद्धांतसुंदरे गणिताध्याये चंद्रग्रहणाधिकारः पंचमः
added in margin by s R₂, no colophon R₃, इति चंद्रपर्व V₂, इति सिद्धांतसुंदरे चंद्रग्रहणाधिकारः V₃,
इति श्रीमत्सकलसिद्धांतवासनाविचारचतुरचित्तचमत्कारिणि सिद्धांतसुंदरे ज्ञानराजविरचिते चंद्रग्रहणाधिकारः पंचमः V₄, no
colophon V₅

⟨अथ ग्रहगणिताध्याये सूर्यग्रहणाधिकारः⟩

भूपृष्ठगर्भगनरौ न समानकाले
चन्द्रावृतं दिनकरं प्रविलोकयेताम् ।
दृक्सूत्रकं रविगतं क्षितिगर्भगस्य
दर्शान्त एव विधुरेति न पृष्ठगस्य ॥ १ ॥

f. 26 I

5 f. 22v R₂

तत्सूत्रयोरपमवृत्तगमन्तरालं
तल्लम्बनं नतिरिहोत्तरदक्षिणं यत् ।
नो लम्बनं भवति मध्यविलग्नतुल्ये
भानौ द्वयं न सममण्डलमध्यगे ऽस्मिन् ॥ २ ॥

चेन्मध्यलग्नजनितांशमितेरभावः
स्वीयोदये युग ४ घटीमितलम्बनं स्यात् ।
तत्साधितं सुमतिभिर्बहुधानुपातैः
सूर्योदये ऽपि समये ऽभिमते मुनीन्द्रैः ॥ ३ ॥

10 f. 16v V₄

Chapter opens श्रीवरदमूर्तिर्जयति I Verse 1 2 भूपृष्ठगर्भगनरौ] भूमध्यपृष्ठगनरौ B₅ समानकाले]
स (म)^{marg,s}मानकाले I 3 चन्द्रावृतं] चन्द्रावृतं M₂V₄ प्रविलोकयेताम्] न विलोकयेताम् V₂ 4 दृक्सूत्रकं]
दृक्सूत्रक V₅ रविगतं] रविगत R₂R₃V₅ 5 दर्शान्त] दशान्त B₅ विधुरेति] [विधुरे]विधुरेति V₂
Verse 2 6 तत्सूत्रयोर] तत्सूत्रर B₅ 8 मध्यविलग्न] मध्यमलग्न V₅ 9 भानौ] भानो V₅ मध्यगे]
मध्यगे V₄ Verse 3 numbered 31 R₃ 10 जनितांश] जनतांश M₂R₂R₃V₂ 11 ४] om.
B₅M₂R₂R₃V₄V₅ घटी] ण्टी V₄ 12 तत्साधितं] तसाधितं V₄, तत्साधतं V₅ सुमतिभिः] सुमति B₅
बहुधानुपातैः] बहुधापातैः B₅ 13 मुनीन्द्रैः] म[नु]नीन्द्रैः B₅, मुनीन्द्रैः १४ V₅

।पर्वान्ते ऽवनिगर्भगोदयकुजे भानौ भवेद्भूदलं ८००
 कोटिर्भास्करयोजनश्रुतिभुजे ।कर्णः ।स्वसूर्यान्तरम् ।
 तत्किं स्याद्रविचन्द्रयोजनमयश्रुत्यन्तराले भुजे
 कोटिर्लम्बनयोजनानि परमज्या <३४३८> सङ्गुणान्याहरेत् ॥ ४ ॥

f. 23 V₅

f. 17v R₃, f. 62v V₄

शीतांशुकर्णेन कला भवन्ति
 पादोनतानाः ४८ । ४५ खरसा ६० हतास्तु ।
 गत्यन्तराप्ताघटिकाचतुष्कं ४
 स्याल्लम्बनं मध्यममुद्गमे ऽस्ते ॥ ५ ॥

5

पर्वान्तसायनतनुज्यकया जिनां।श-
 जीवा १३९७ हताथ विहृता निजलम्बमौ।व्या ।
 लब्धं निजोदयगुणो ऽत्र खमध्यलग्न-
 क्रान्त्यंशकाक्षलवसंस्कृतिजा नतज्या ॥ ६ ॥

f. 26v I

10 f. 20 B₅

Verse 4 1 पर्वान्ते] वीं पते M₂, स्तो^३? पर्वान्ते V₅ भानौ भवेद्भूदलं] भानोद्भवेद्भूदलं M₂ ८००] om.
 V₅ 2 कोटिर्भास्कर] कोटिर्भास्कार R₂V₅, कोटिर्भास्कर V₄ योजन] योजनः M₂ कर्णः] [के]कर्णः V₄
 3 द्रविचन्द्रयोजनमय] द्रवियोजन-मया V₄ मय] मये B₅, मयः I मयश्रुत्यन्तराले] मयेमत्यंतराले M₂
 श्रुत्यन्तराले] श्रुत्यं(त)_{marg}राले R₃ 4 योजनानि] [x]योजनानि I योजनाभि M₂ ज्या] ज्या [x] I
Verse 5 6 तानाः] ताना ४८१५ B₅, तानाः ४८ R₂, तानाः ४८ R₃ तानाः ४८ । ४५ खरसाहतास्तु]
 तानाः खरसाः ६० रसास्तु ४८ V₅ ६०] om. B₅IM₂V₂ 7 गत्यन्त] गुत्यांत V₄ राप्ता] रास्ता B₅
 घटिकाचतुष्कं] घटिकाचतस्रं M₂, घटिकाश्चतस्रः R₂R₃ ४] om. B₅IM₂R₂R₃V₂V₄ **Verse 6**
 not numbered V₂ 9 पर्वान्तसायन] पर्वसाय(न)_{marg} I तनु] [तु]तनु M₂ ज्यकया] ज्यकाया V₄
 10 जीवा] जीवा^{१३९७} V₂ १३९७] १३९७ om. B₅IM₂R₂R₃V₄V₅ हताथ] हताय M₂, हताथ V₄, हतरथ V₅
 लम्ब] लंबा V₅ 11 निजो] निजौ R₃ निजा V₄ लग्न] लग्नं B₅M₂R₂R₃V₅ लग्न[लग्न] V₂ लग्न[ध्य]
 V₄ 12 काक्ष] काख्य V₅ लव] वे^३ल V₂ संस्कृतिजा] संस्कृजा V₄ नतज्या] नजान्या V₅

सा संहतोदयगुणेन हृता त्रिमौर्व्या <३४३८>

तल्लब्धवर्गनतभाग।गुणोत्थवर्गौ ।

f. 23 R₂

विश्लेषितौ पदमतो भवतीह ।दृष्टि-

f. 27 V₄

क्षेपस्तु तत्तिभगुणोद्भववर्गयोर्यत् ॥ ७ ॥

विश्लेषमूलमिह दृग्ग।तिसञ्ज्ञशङ्कु-

5 f. 63 V₂

हारो भवेत्ति भगुणार्ध <१७१९> कृतिर्नराप्ता ।

मध्याह्नलग्नतपनान्तरमौर्विकाया

हारेण लब्धमिह लम्बननाडिकाः स्युः ॥ ८ ॥

दर्शे विलम्बनमिदं स्वमृणं विधेयं

न्यूनाधिके सति विवस्वति मध्यलग्नात् ।

10

राशित्रयोनतनुभानुविशेषजीवा

वेदा ४ हता त्रिगुण <३४३८> हल्लघुलम्बनं वा ॥ ९ ॥

Verse 7 1 संहतो] सेहितो V₄ हृता] हता V₅ त्रिमौर्व्या] त्रिमौर्व्या V₄ 2 तल्लब्ध] [ल]तल्लब्ध B₅, लल्लब्धवर्ग V₅ वर्गनत] वर्गा[योर्य]नत R₂, वर्गायोर्यन (तभागगुणोत्थवर्गौ विश्लेषितौ पदमतो भवतीह दृष्टिक्षेपस्तु तत्तिभगुणोद्भव वर्गायोर्यत् ७ उ^१ल ५) marg R₃ गुणोत्थवर्गौ] गुणे(र)त्थवर्गौ I, गुणोत्थवर्गौ R₂, गुणोदे^१ [त]थवर्गौ V₄, गुणास्यवर्गौ V₅ 3 विश्लेषितौ] [विश्लेषमूलमिह दृग्गति]विश्ले(f)षतौ I, विश्लेषतौ M₂, विश्ले(f)षतौ R₂, विश्लेषितो V₅ [दृष्टि] दृष्टिः B₅, दृष्टी M₂ 4 क्षेपस्तु] क्षेपस्तु V₄ तत्तिभ] तत्ति(भ) marg,s [x] R₂ गुणोद्भववर्गयोर्यत्] गुणोभववर्गयोर्यत् V₅ वर्गयोर्यत्] वर्गायोर्यत् R₂ **Verse 8** 5 दृग्ग[ति] दृ[ष्टि]ग्गति I शङ्कु] (शं) marg,s कु R₂ 6 हारो भवेत्ति] हारो हारो भवेत्ति V₄ हारो भवे त्रि V₅ गुणार्ध] गुणे द्वे V₄ कृति] वृत्ति V₅ नराप्ता] नरो(ना) marg,s १२। R₂ नरा। १२। ता^१ R₃ 7 लग्न] ल[x]ग्न B₅ मौर्विकाया] मौर्विकाया V₅ 8 नाडिकाः] नाडिका(:) subl I, नाडिका M₂V₄V₅ स्युः] स्यु R₂ **Verse 9** not numbered V₂ 9 दर्शे] [x]दर्शे I 11 त्रयोनतनु] त्रयोनुतनु M₂V₅, त्रयोनुतनु V₄ विशेष] वि[x]शेष I 12 वेदा] वेद V₄, वेदा x ता V₅ ४] om. B₅M₂V₅ हता] ह[र]ता M₂ हल्लघु] हल्लघु R₂R₃ हत्तु V₅

तद्विचित्रिभोद्धवसमुन्नतमौर्विकाग्रं
त्रिज्या हृतं स्फुटमिति प्रवदन्ति केचित् ।
दृक्क्षेपादपहृतात्खनगै <७०> नतिः स्या -
।न्मध्यज्यकादिगिति तत्परिसंस्कृतेषुः ॥ १० ॥

f. 27 I

स्पष्टो ऽसकृत्स्थिरविलम्बनसंस्कृतो ऽपि
दर्शस्तदुद्धवशरो नतिसंस्कृतो ऽस्मात् ।
ग्रासस्थिती स्थितियुतोनितदर्शतस्तु
कार्यं विलम्बनमनेन पृथक्।स्फुटेन ॥ ११ ॥

5

f. 63v V₂

स्पर्शो ऽथ मुक्तिसमयः क्रमतः स्थिती स्त -
स्त।न्मध्यकालविवरे तरणिग्रहे । ऽत्र ।

10 f. 18 R₃, f. 17v

V₄

धूम्रो ऽल्पके ऽर्धिततनावसितो ऽथ बभ्रुः
सर्वग्रहे विधुरिनस्तु सदैव कृष्णः ॥ १२ ॥

Verse 10 marg. note (by scribe) accompanies verse त्रिभोनलग्नक्रांतिः अक्षांशाश्च अनयोः संस्कृतिनंतांशाः नवति शुद्धा उन्नतांशा तेषां ज्या तया घ्नं लंबनं V₂ 1 तद्विचित्रिभोद्धव B₅, तद्विचित्रिभोद्धव M₂ भोद्धवसमुन्नत] भोद्धव (समु)_{marg,s}न्नत R₂, भोद्ध [r]वसमुन्नत V₄ 2 हृतं] हृता B₅ हतं M₂ हते V₅ 3 दृक्क्षेपादपहृतात्खनगै <७०>] दृक्क्षेपकाथ हृतात्खनगै B₅, दृक्क्षेपकाथ हृताच्च नगै M₂, दृक्क्षेपकाथ हृताच्च नगै ७ R₂R₃ दपहृता] दप[म]हृता V₂ त्वनगै <७०> नतिः] त्वाखगैर्नतिस्या V₅ नतिः] नतिः (:) _{marg} I 4 ज्याका] ज्य[या]का V₂ तत्परि] (त)_{marg,s}त्परि R₂ त्परि R₃ संस्कृतेषुः] सं[x]स्कृतेषुः I, संस्कृतेषु M₂V₄V₅ **Verse 11** 5 स्पष्टो ऽसकृत्स्थिरविलम्बन] स्पष्टो विसंस्कृतच्छरविलंबन B₅, स्पष्टो सकृ[x]त्स्थिरविलंबन I, स्पष्टो विसंस्कृतविलंबन M₂, स्पष्टो विसंस्कृतिविलंबन R₂, स्पष्टो विसंस्कृतिविलंबन R₃, स(प)ष्टो (ऽ)_{supl}सकृत्स्थिरविलंबन V₂, स्पष्टो ऽसकृत्स्थिरविलंबन V₄ विलम्बन] विलंबनं V₅ 6 दर्शस्तदुद्धव] दर्शस्तु तद्व[]व B₅, दर्शस्तु तद्वव M₂R₂R₃ नति] नतिति B₅, न(f)त M₂ संस्कृतो ऽस्मात्] संस्कृतः स्यात् (॥)_{supl} R₂ संस्कृतः स्यात् R₃ 7 ग्रासस्थिती] ग्रासः स्थितिः B₅, ग्रासस्थिति M₂V₅, ग्रासः स्थितिः R₂R₃ स्थितियुतो] स्थिति-युतो V₄ नितदर्श] नि[द]तदर्श I 8 पृथक्स्फुटेन] पृथक्स्फुटे स्मिन् B₅M₂ पृथक्स्फुटे स्मिन् I मुहुः स्फुटे स्मिन् V₂ पृथक्स्फुटे ऽस्मिन् V₄ मुहुः स्फुटो स्मिन् V₅ **Verse 12** 9 मुक्ति] भुक्ति V₄ समयः] समय B₅R₂R₃ समयं M₂ क्रमतः] क्रमत IM₂ क्रमश V₅ 10 न्मध्यकाल] न्म का ध्यल M₂ विवरे] विवरे V₄ तरणि] तरणी R₂ [ऽत्र] (ऽ)_{supl}त्र R₂ 11 धूम्रो] धूमो M₂, धूम्रो V₂ ऽल्पके] ल्पक M₂, ल्यंके V₄ ऽर्धित] सित V₅ तनावसितो] तनौव I, तनाव (ऽ)_{supl}सितो R₂, तनावसितो R₃, तनावसितौ V₅ 12 ग्रहे] ग्रहो V₅ विधुरिनस्तु] विधुरितस्तु B₅ कृष्णः] कृष्ण (:) _{supl} R₂ after verse 12 इच्छं श्रीमन्नागनाथात्मजेन० संपूर्णो यं सूर्यपवाधिकारः V₅

अथ वासनाश्लोकाः ॥

।दर्शान्तोदयलग्नकापमगु।णादग्रानुपातद्वया -

f. 20v B₅, f. 23v R₂

त्सञ्चारादुदयज्य।केति गदिता दृग्ज्या खमध्योदयात् ।

f. 10 M₂

त्रिज्याया मुदयज्यकामितभुजस्तत्किं भवेद्दृग्ज्य।या

f. 23v V₅

लब्धं दोरपवृत्तपूर्वपरया तन्मध्यलग्नज्ययोः ॥ १३ ॥

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यद्वर्गान्तरतः पदं निगदिता कोटिः स दृक्क्षेपक -

स्तत्कर्णस्त्रिगुण ३४३८ स्तयोरथ भुजः सा दृग्गतिः शङ्कुवत् ।

मध्याह्नोदयभास्कुरान्तरगुणे त्रिज्या मिते लम्बनं

f. 27v I

चत्वारः ४ किमभीप्सिते ऽथ यदि तत्त्रिज्यामिता दृग्गतिः ॥ १४ ॥

f. 27 V₂

इष्टायां किमिति त्रिराशिकयुगे त्रिज्या हरौ तद्धति -

10

वेदै <४> रप्यपवर्तितैकभवनज्या वर्गतुल्यः पुनः ।

दृग्गत्याप्यपवर्तितो ऽत्र भवति छेदाह्वयस्तद्धता

लग्नार्कान्तरमौर्विका स्फुटमिदं नाड्यादिकं लम्बनम् ॥ १५ ॥

1 अथ वासनाश्लोकाः] अत्रोपपत्ति (:) ^{supl} R₂, अत्रोपपत्ति R₃, अथ वासनाश्लोकः V₂, अत्र वासनाश्लोकाः V₅
Verse 13 misnumbered 12 I 2 दर्शान्तो] दर्शांतौ R₃ दयलग्नका] om. V₄ लग्नकापम]
लग्नकापम V₅ ग्रानुपात] ग्रानपात B₅M₂ द्वया] द्वये I, द्वय (r)(t) ^{marg} V₂ 3 त्सञ्चारा] संचारा
B₅IM₂ ज्यकेति ज्य (के) ^{marg,s} ति I गदिता] [x]विता R₂ खमध्यो] स्वमध्यो M₂ ख [r]मध्यो V₄
4 त्रिज्याया] त्रियोया V₅ भवेद्दृग्ज्यया] भवेद्दृया B₅, भवे दृग्ज्यया IV₂V₄V₅, भवेद्दृग्ज्यया R₃ 5 दोरपवृत्त]
दोरुपवृत्त M₂V₄; दोर [] पवृत्त V₂ ज्ययोः] ज्ययो (:) ^{supl} R₂, ज्ययो R₃, ज्यया V₄ **Verse 14**
misnumbered 13 IV₂ 6 यद्वर्गान्तरतः] यद्वर्गान्तरतः R₃, यद्वर्गांतरजं IV₂V₄ निगदिता कोटिः]
निगदितात्कोटिः V₄ 7 गुण] गुण [r] I ३४३८] om. R₂R₃V₅ भुजः] भुज M₂ सा] स्या M₂V₅
दृग्गतिः] दृग्गति V₄ 9 चत्वारः] चत्वार (:) ^{supl} R₂ ४] om. R₂R₃V₄V₅ किम] किम [r]
V₅ भीप्सिते] मीप्सिते R₃ तत्त्रिज्या] तत्रिज्या V₅ **Verse 15** misnumbered 14 B₅IV₂
10 इष्टायां] इष्टयां V₅ युगे] युते I तद्धति] तह[?]ति B₅ तद्धति IV₄ त x ति V₅
11 रप्यपवर्तितैक] रप्यवर्तितैक B₅, रप्यतिव fx तितैक V₅ तुल्यः] तुल्या V₅ 12 दृग्गत्या] दृग्पता V₅
पवर्तितो] पवृत्तितो I, पवर्तितो M₂, पवर्तितौ R₂R₃ ह्वयस्त] ह्वय [x]स्त I, ह्वयास्त R₂ दृता] दृतो I, दृता
R₃, धृता V₅ 13 लग्नार्कान्तर] लग्नार्कंतर B₅M₂, लग्नार्कंतर V₄ मौर्विका] मौर्विका B₅ योर्विका R₃
स्फुट] स्फट B₅ after verse 15 इति ग्रहस्योपपत्तिः V₅

इत्थं श्रीमन्नागनाथात्मजेन
 प्रोक्ते तन्त्रे ज्ञानराजेन रम्ये ।
 ग्रन्थागाराधारभूते प्रभूते
 युक्त्या युक्तः सूर्यपर्वाधिकारः ॥ १६ ॥

f. 28 V₄

Verse 16 not numbered B₅IR₃V₂ om. (given after verse 12) V₅ 1-3 नाथा —
 प्रभूते] om. B₅ 1 जेन] जन R₃ 2 प्रोक्ते] प्रोक्त V₄ रम्ये] रम्ये (॥)^{supl} R₂ रम्ये
 V₄ 3 ग्रन्थागारा] ग्रन्था [x](गा)_{marg} रा R₂ ग्रन्थागतरा R₃ 4 युक्त्या युक्तः] युक्त्याद्युक्तः B₅ युक्त्या
 द्युक्तः M₂ युक्त्या युक्तः V₄ **Colophon** इति श्रीसिद्धांतसुंदरे सूर्यग्रहणाधिकारः B₅ इति
 श्रीमत्सकलसिद्धांतवासनाविचारचतुरचतुरचित्तचमत्कारकारिणि सिद्धांतसुंदरे सूर्यग्रहणाधिकारः I इति सूर्यग्रहणाधिकारः
 M₂ (इति श्रीनागराजात्मजज्ञानराजविरचिते सिद्धांतसुंदरे गणिताध्याये सूर्यग्रहणाधिकारः षष्ठः)_{marg,s} R₂ om.
 R₃ इति सूर्यपर्व V₂ इति श्रीमत्सकलसिद्धांतसुंदरे सूर्यग्रहणाधिकारः ६ V₄ om. (given after verse
 12) V₅