

A Nineteenth Century Sanskrit Treatise on the Revolution of the Earth: Govinda Deva's *Bhūmibhramaṇa*

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I. Introduction

Govinda Deva Śāstrī

The author of the *Bhūmibhramaṇa* identifies himself in the colophon as “Govinda, the pupil of Lajjāśaṅkara.” The two names, configured in this relationship, and taken together with the content of the text and with the location of the manuscript in the collection of the Banaras Sanskrit College, makes an identification of the author possible as Govinda Deva Śāstrī, an astronomer active in Banaras in the mid-nineteenth century. His biography is given by Pingree as follows: “Govinda Deva Śāstrī (d. 1870): The nephew of Bāpu Deva Śāstrī, and a Cittapāvana Brāhmaṇa from Mahārāṣṭra, Govinda became instructor at the Sanskrit College in Benares in 1859 at the age of 25, and served in that capacity until his death in 1870.”¹

From Sudhākara Dvivedī's *Gaṇakatarāṅginī* we also learn that Govinda Deva knew English, and was skilled in mathematics and poetry. He produced the first edition of Jayadeva's Sanskrit drama, the *Prasannarāghava*, serially in *The Pandit*, and also the edition of Rājaśekhara's drama, the *Bālarāmāyaṇa*.² Govinda Deva also wrote an essay for *The Pandit* on the preferability of the tropical (*sāyana*) method of astronomy of the Europeans.³ Dvivedī identifies Bāpu Deva Śāstrī, Govinda's uncle, as his teacher and supporter. According to rumors still circulating in Banaras later in the nineteenth century, Govinda was offered the position in the Sanskrit College over a better candidate because of Bāpu Deva's intercession with the Col-

¹ *CESS* A2 p. 142. Pingree's chief source is the *Gaṇakatarāṅginī*. From this information we can also gather that Govinda Deva was born in 1834, and that he died at the early age of 36. In *CESS* A2 Pingree did not identify him with the author of the *Bhūmibhramaṇa*, listed on p. 136, but the link to Lajjāśaṅkara in the colophon makes this identification clear.

² The *Prasannarāghava* appeared in vol. 2 (1867-68) of *The Pandit and the Bālarāmāyaṇa* in vol. 3 (1868-69). Both were subsequently reprinted as separate volumes.

³ “Sāyanavicāra,” *The Pandit* 1 (1866-67) 32-35.

lege's Superintendent, James Ballantyne.⁴ With Ballantyne, Govinda collaborated on an edition and translation of the *Yogasūtra*.⁵

Govinda's demonstrated interest in Sanskrit literature explains in part his motivation in writing a poem in ornate Sanskrit verses about the revolution of the earth. More important for our consideration are his knowledge of English, his publication on the "European" tropical method of astronomy, and his affiliations with Bāpu Deva, Lajjāśaṅkara, and James Ballantyne.⁶ Through Bāpu Deva and Lajjāśaṅkara, Govinda can be connected with the nineteenth century movement in Sanskrit astronomy begun by Lancelot Wilkinson. Bāpu Deva was one of the principal figures in this school. He was given his position in the Sanskrit College in Banaras through Wilkinson's intervention, and carried the movement's agenda with him to Banaras, where its trajectory can be followed in the publications of *The Pandit*, (the Sanskrit College's official organ,) and elsewhere. There in Banaras the pandits initially inspired by Wilkinson participated in some of Ballantyne's projects as well.⁷

Several studies of Wilkinson and his school have been published recently.⁸ Here it will be sufficient to note only some relevant information. Sometime around 1829, Wilkinson was appointed the British political agent in the princely state of Bhopal. Wilkinson believed that the best way to introduce the modern Coperni-

⁴Sudhākara Dvivedī, *Gaṇakatarāṅginī* (Benares: 1892) 131-32. Govinda incidentally is the last author named in Dvivedī's chronologically arranged history of astronomers. According to Dvivedī, Govinda had a falling out with Bāpu Deva, and the two were not on speaking terms in later life. Govinda's specification of Lajjāśaṅkara as his guru might fix the date of the completion of the *Bhāmibhramaṇa* as sometime after this rift.

⁵Published serially in *The Pandit* 3-6 (1868-72) and then separately. Ballantyne had edited the first two chapters earlier, and Govinda completed the work. Further revised and reprinted many times.

⁶He might have learned his English in the English classes required for some staff and for advanced students in the Sanskrit College. See Michael Dodson, "Re-Presented for the Pandits: James Ballantyne, 'Useful Knowledge,' and Sanskrit Scholarship in Benares College during the Mid-Nineteenth Century," *Modern Asian Studies* 36.2 (2002): 284-85. Govinda also contributed an obituary of Viṭṭhala Śāstrī, the other prominent "modernizing" figure in the Sanskrit College until his death in 1867, *The Pandit* 1 (1867) 177-78.

⁷On Bāpu Deva in Banaras, see Dodson, "Represented for the Pandits," 291-93 and passim.

⁸C.A. Bayly, *Empire and Information* (Cambridge: Cambridge University, 1996) 257-60; Richard F. Young, "Receding from Antiquity: Indian Responses to Science and Christianity on the Margins of Empire," *Kokusai-gaku-Kenkyū* 16 (*Meiji Gakuin Ronso* 595) (1997) pp. 241-74; C. Minkowski, "The Paṇḍit as Public Intellectual: The Controversy over *virodha* or Inconsistency in the Astronomical Sciences," in ed. Axel Michaels, *The Pandit: Traditional Sanskrit Scholarship in India (Festschrift P. Aithal)* (New Delhi: Manohar Publications, 2001) pp. 83-102; Kim Plofker, "Derivation and revelation: the legitimacy of mathematical models in Indian cosmology," in ed. Teun Koetsier, *Mathematics and the Divine* (Amsterdam: forthcoming).

can system of astronomy to learned Indians, especially to the whole class of Indian astronomer/astrologers, was through the medium of Sanskrit, and in particular through the Siddhāntic model of the cosmos. He set up a school in Sihore, (near Bhopal,) devoted to the study of the Jyotiṣa Siddhāntas. Since the Siddhāntas already rejected much of the Purāṇic cosmology, Wilkinson reasoned, and since they already made use of many of the necessary principles of geometry, trigonometry, and arithmetic, it would be a short step to move from the Siddhāntic to Copernican scientific models, which could be presented in a way that would not alarm the whole class of Jyotiṣa *paṇḍits*. He therefore encouraged the publication of works in Sanskrit and other Indian languages that endorsed the Copernican model, while characterizing it as an extension of the astronomical Siddhāntas, and at the same time distancing the Siddhāntas from the views of the Purāṇas. Wilkinson's project was decidedly "Orientalist" in the old sense of the term, viz. that the indigenous Indian knowledge systems, properly transformed, could serve as the basis for future scientific education and communication in India. Bāpu Deva Śāstrī continued to carry out this Sihorean project during his career in Banaras.

The Sanskritic Nature of the *Bhūmibhramaṇa*'s Astronomy

The *Bhūmibhramaṇa* is a short, elliptical work whose stance toward its subject matter is not always self-evident. It alludes to many arguments that are not stated fully. This work of Govinda Deva, Bāpu Deva's nephew and protégé, can best be understood in relation to the history of Wilkinson's movement.

There is, first of all, the Sanskritic nature of the text. Why write a modern scientific treatise in Sanskrit at all in the nineteenth century, and why in relatively ornate Sanskrit at that?⁹ We can understand from the historical context that Govinda was committed to expounding the heliocentric view from within the tradition of the Jyotiṣa Siddhāntas, and so returned to the language of that science and the poetic form that it often took. This commitment also explains the lengthy citation of the *Siddhāntaśiromaṇi* (vss. 31-34,) and the reliance on several of its cosmological arguments. The apparently eccentric formulation of a number of central topics is better understood in relation to Bhāskara and other authors of Jyotiṣa Siddhāntas. Govinda's formulation of gravitational attraction, for example, stays close to the terms in which Bhāskara discussed it. There is, furthermore, the appeal to the sheer authority of a Sanskrit text, known only as the *Bhāṣya* in this work; an argument

⁹At the same time it must be stated that the *Bhūmibhramaṇa* does not constitute high poetic art. There are even some expressions from modern Indic languages that have seeped into the language of the text, for example the ubiquitous use of the Sanskrit preposition *upari* in the fashion of the Hindī/Marāṭhī postposition *ūpar/upar*.

in favor of the earth's rotation is based on the exact wording of this Bhāṣya.¹⁰

Though it expounds a heliocentric model, the treatise does not begin from the perspective of the Sun or place the earth in an elliptical orbit inclined on its axis, but instead maintains the perspective of the earth. While setting the earth in motion, and describing its daily revolution and motion above and below the solar plane, Govinda does not state in so many words that the earth circles the sun. By not doing so, he remains closer to the realm of possibilities imagined by the Siddhāntas of the past, which had included Āryabhaṭa's suggestion of the earth's spinning on its axis.¹¹ Indeed, Govinda is able to stay closer to a Siddhāntic vision of the cosmos by leaving certain things implied, but unsaid. The *Bhūmibhramaṇa* contains numerous passages that are susceptible to more than one reading. As with many Sanskrit poetic works, this ambiguity is sometimes by design.

Tidal Motions

The most distinctive argument that Govinda makes in the *Bhūmibhramaṇa* is that the rotation of the earth can be inferred from the tidal motion of the earth's waters. Govinda makes the assertion several times, though he argues for it in a rather compressed way. Siddhāntic treatises had not previously discussed the tides as part of cosmology. By the mid-nineteenth century, the European scientific understanding of the tides included most of the theory still accepted today, as developed by Newton, Laplace and others.¹² Govinda did not draw on these theories, however, but turned instead to much older European scientific materials: the arguments of Francis Bacon and Galileo. The main reason for this must have been twofold: first of all because Galileo and Bacon notably discussed the tides in the context of the proof of the earth's rotation, and second because the *Novum Organum* of Bacon was a text of unusual importance to the Sanskrit College in Banaras in this period. As part of his version of the "Orientalist" project described above, Ballantyne as Superintendent had commissioned the publication of an explanatory edition of the *Novum Organum* in both English and Sanskrit. He hoped to stimulate new science by making available to the pandits versions of seminal scientific treatises. The *Novum Organum*, with its emphasis on empirical observation and the inductive scientific method, was Ballantyne's "foundational text" for this project.¹³

Bacon knew of Copernicus' and Galileo's heliocentric theories, and mentioned them in the *Novum Organum*, but he still thought that the earth was fixed at the

¹⁰See vss. 35-37. I have been unable to identify the text or the passage.

¹¹*Āryabhaṭīya*, *Golapāda* 9-10, and subsequently discussed by later Siddhāntins.

¹²David Edgar Cartwright, *Tides: A Scientific History* (Cambridge: Cambridge University Press, 1999).

¹³Dodson, "Re-Presented for the Pandits," 285-86.

center of the cosmos. He had written an independent work on the tides, the “De fluxu et refluxu maris,” and there linked the phenomena of the tides to the natural motion of the cosmos as a whole. This natural motion is observed to be from east to west, fastest in the stars, and then progressively slower all the way down to the faint, background motion of the earth's waters. The reason the waters do not all flow in the same direction has to do with the interference of currents and with obstacles to their continuous flow. The ebb and flow of the tides is caused in part by the waters' running up against the continents and reflecting off of them.

In the *Novum Organum*, then, Bacon renewed this argument, but left it open as a matter to be decided by experiment. Did the waters have an observable, faint tendency to flow from east to west? Were the times of tides on the Atlantic correlated in such a way that they showed an overall northward direction, thereby confirming the transformation of the general directional tendency of the waters in the confined space between continents? If so, Bacon proposed, it could be concluded that the stars and the rest of the heavenly bodies revolved, while the earth did not. If, on the other hand, the general direction of the motion of the waters was in the other direction, this would confirm the revolution of the earth. [NO 2.36.]

Bacon also mentioned Galileo's theory of the heliocentric universe, and of the rotating and revolving earth. He mentioned Galileo's proposal that the tides were caused by these two motions, and that the motion of the tides was a proof of the rotation of the earth [NO 2.46.] In fact this had been Galileo's original, and, Galileo thought, most persuasive argument for the revolution of the earth.

Thus Govinda, who was based at the Sanskrit College under Ballantyne, would have come upon a discussion in a highly privileged text in the College, the *Novum Organum*, about tidal motions as a proof or disproof of the rotation of the earth. This means of proof has been adapted to the *Bhūmibhramaṇa*. There is no mention of the influence of the moon in Govinda's discussion of the tides. That was not a matter of interest to Bacon and Galileo, since for them it did not serve to prove or disprove the earth's rotation.

The Parts of the Argument

The subcolophons of the text divide the work into an introduction and five sections, though Govinda describes only four sections in the description of the work that he gives in its fourth verse. In the introduction, Govinda links his work to the scientific legacy of the Jyotiṣa Siddhāntas. The first section is devoted to proving that the earth is a sphere, which is done using an argument from the Siddhāntas about the elevation of the pole star from the horizon for someone traveling north.

In the second section, Govinda argues both for the daily and annual motion of the earth, for the former by appeal to an analogy and also by argument from the tidal motions of the waters. For the latter, annual motion, Govinda does not so

much advance arguments in favor as show that the phenomena associated with the sun's annual motion - the seasons and the change in the length of the day - can be explained just as easily by assuming that it is the earth that moves.

The third section is intended to show that the earth is without support. Govinda initially discusses the earth's attraction power. From the way the section is constructed, it appears that Govinda is venturing toward saying that the earth's behavior in relation to other planets is caused by gravitational forces, but the only gravitational attraction he describes is the earth's power to hold things onto itself, a notion already advanced in the Siddhāntas.¹⁴ Beyond this he draws on the *Siddhāntaśiromaṇi*, citing it at length, constructing its picture of the earth as a sphere, and showing that people can live on any part of the sphere of the earth and think that it is below them. In returning to these Siddhāntic arguments there is implied a rejection of the Purāṇic model of a flat earth supported from beneath. If the earth is already accepted by the Siddhāntas to be a sphere free of support and surrounded only by space, the argument seems to further imply, then it is free to move, both spinning on its axis and also moving through space.

The fourth section argues that the sun, not the earth, is at the center of the "sphere of stars" and the "sphere of space." These are two features of spherical astronomy that are drawn from the Siddhāntas. Govinda's argument here is roughly that since the earth is moving, (around the sun, though he does not explicitly say this,) then the earth cannot be at the center of the system; the sun must be. Here is also inserted the proof of the rotation of the earth on its axis by appeal to the tidal motions of the earth's waters, though why this longer version of the argument is not given in the second section, where the earth's rotation is the topic of consideration, is not clear.

The final section, the critique of other views, is directed at certain Purāṇic and Siddhāntic positions. Govinda accepts the Purāṇic premise that the duration of the life of the cosmos (kalpa), which lasts for a thousand eons, is one daytime in the life of Brahmā, the creator god. Since the kalpa is one daytime for him, it follows that Brahmā must see the sun for the kalpa's whole duration. Govinda's question is simply this: where can Brahmā be located within either the Purāṇic or Siddhāntic creation so that he can see the sun all the time? Govinda goes through various possibilities conceivable in the older cosmologies and rejects them. Govinda's answer - that Brahmā is in the highest, outermost sphere of heaven - would solve the problem for the Siddhāntic model as well, though earlier Siddhāntic authors had not placed Brahmā there. The argument is scholastic in format, and does not single out the heliocentric model particularly well.

There is only one extant manuscript of the *Bhūmibhramaṇa*. We may therefore conclude that the work did not enjoy a great success. One can offer the conjecture

¹⁴See for example *SŚB Bhuvanakośa* vs. 6.

that the work was intended for publication in *The Pandit*, but did not appear in print. Still, the extant manuscript is evidently a copy, and so we must suppose that the work enjoyed at least some circulation. It is worth publishing here for the light that it sheds on the history of the Sihore-Banaras school of renewal of the Jyotiṣa Siddhāntas.

The Manuscript and the Edition/Translation

The single manuscript of the *Bhūmibhramaṇa* is preserved in the collection of the Banaras Sanskrit College, as Sarasvatī Bhavan Accession No. 4469, Catalogue No. 35616.¹⁵ It consists of two paper folios, written in Devanāgarī, with 13-18 lines on each page. No date is given for the work or for the manuscript. No scribe is named. There are marginal corrections in the same hand as the text.

As discussed in the notes to the translation of verses 2 and 4, Govinda says that the work contains fifty-nine verses, but the manuscript contains only fifty-five, with one verse repeated. The missing verses must be lost from the later sections of the text. The manuscript has smaller lacunae, as can be judged from the metrical deficiencies of certain verses. These lacunae have been restored by conjecture, and are indicated by square brackets in the text. Other minor emendations to the text can be found by reference to the apparatus. For example, the scribe does not carefully distinguish v from b, or s from ś, and these are clarified in the edition. The format of the translation and notes is straightforward.

Final Comments and Acknowledgements

This edition and translation were begun nearly ten years ago, as part of the research activities of the Working Group on the Exact Sciences of the erstwhile Dharam Hinduja Indic Research Center based at Columbia. The manuscript was offered to me because it was a short, single manuscript on a relatively non-technical topic, and hence was presumed to be easier for a neophyte to work on. Figuring out the manuscript's context and meaning turned out to be rather difficult, even for specialists, exactly because the work is sui generis, and required the study of many other cosmological treatises in various traditions. Because of the nature of the text, I am still uncertain of several features of its translation and explanation. It is time, however, to let others have a chance to study it, in the hope that they can further clarify the meaning of this unusual work. If another, complete and clear manuscript of the *Bhūmibhramaṇa* were to come to light, a number of questions could be answered quickly. More historical research on Govinda Deva Śāstrī and the history of the Sanskrit College in mid-nineteenth century Banaras may also

¹⁵Another serial number is written on the top leaf of the manuscript - 1052. Also Jyau(tiṣa) Naṃ(bar) 190. Colophon: iti śrīlajjāśaṃkarachātragoṃḍakṛtaṃ bhūmibhramaṇaṃ samāptam.

illuminate this text further. My thanks to David Pingree for help at many stages of the preparation of this work, to Kim Plofker, and to the anonymous reviewer for this journal. Any errors are solely mine.

Abbreviations and other relevant bibliography

- CESS* David Pingree, *Census of the Exact Sciences in Sanskrit, series A*, 5 volumes, Philadelphia: American Philosophical Society, 1970-1994.
- Dialogue* Galileo Galilei, *Dialogue Concerning the Two Chief World Systems*, tr. Stillman Drake. New York: Modern Library, 2001.
- Fs. Pingree* *Studies in the History of the Exact Sciences in Honour of David Pingree*, ed. C. Burnett, J. P. Hogendijk, K. Plofker and M. Yano, Leiden-Boston: Brill, 2004.
- MS* Manuscript – Sarasvatī Bhavan Accession No. 4469, Catalogue No. 35616.
- NO* Francis Bacon, *Novum Organum*, ed. J.E. Creighton. New York, 1899.
- SŚB* *Siddhāntaśiromaṇi* of Bhāskara, ed. Bāpudeva Śāstrī, rev. Gaṇapati-deva Śāstrī. Kashi Sanskrit Series 72 Banaras, 1929.

- Āryabhata, *Āryabhatīya* ed. K.S. Shukla, New Delhi: Indian National Science Academy, 1976.
- Francis Bacon, “De fluxu et refluxu maris,” in ed. Graham Rees, *Philosophical Studies*, Oxford Francis Bacon vol. 6 Oxford, 1996 65-93 & 376-82.
- A Descriptive Catalogue of Sanskrit Manuscripts acquired for and deposited in the Sanskrit University Library, Sarasvati Bhavana.* vol. 9 Jyautiṣa Manuscripts, Banaras, 1963.
- Aristotle, *Meteorologica*, tr. H. D. P. Lee. Loeb Classical Library 397 Cambridge: Harvard, 1952.

II. Text

om śrīgaṇeśāya namaḥ.

maheśagaurīcaraṇaṃ namāmi gaṇeśavāṇīśaraṇo sadā tu
guroḥ tathā pādarajo gṛhītvā karomi bhūmibhramaṇaṃ balen

1

-śaraṇo sadā tu: *MS* is unclear - -śaraṇ- sā (corr. to sa) dā ttū.

apūrvayuktyā pracitaṃ mayā tan navākṣavṛttai racitaṃ subodhaṃ

upendravajrābhir apīndravajrābhidhaiḥ suyuktyā ca purāṇabāhyam 2

calā na śāstre kathitā calā kiṃ vivekatattvoktividāṃ suyuktyā
tayā ca yuktyā pratipāditāṃ tām vadāmi bhūmibhramaṇe sugolāṃ 3

golā caturbhiś ca calāṣṭibhiś ca vṛttair apūrvaiḥ kathitā subodhaiḥ
ākāśagā pañcadaśaprabandhaiḥ śeṣaiś ca kendretaragā mayā ca 4

caturbhiś: catubhiś *MS*.

nirakṣadeśe kṣitijaprasaktau dhruvau janaḥ paśyati yāmyasaumyau
nirakṣadeśād yadi saumyago 'sau udagdhruvam paśyati connataṃ koḥ 5

kṣitijaprasaktau: kṣitijaprasaktau *MS*.

dharā sugolā kathitā mayāto vilokanīyā satataṃ budhaiḥ sā
samo yataḥ syāt paridheḥ śatāmśaḥ samaiva chātra pratibhāty ataḥ sā 6

samāṃ dharāṃ ye pravadanti te 'jñā dhruvonnatir nāsti mate ca teṣāṃ
yadāsti kiṃ sarvaḥkṣitau tathā na samā yataḥ syāt pratipāditā taiḥ 7

samā trikāle na bhavec ca pṛthvī rasā suvṛttā racitā sulokaiḥ
yathātra loke tilamodako 'sti samastadikṣu pracitā tathaiva 8

iti golābhūpratipādikāni ślokāni

calādhārāyāṃ prathitāsti śaktis tathāpi nādhaḥ pṛthivī prayāti
na cordhvadeśe 'pi yathā mahrerukam apāgudakkrāntivaśena yātā 9

-vaśena: -vasena *MS*. mahrerukam: see notes in Tr.

mahreru loke kathitaṃ sugolaṃ cārvā.ngikavāmadṛśāṃ prasiddham
gatiś ca pūrvāparam eva tasya suyaṣṭividham vahati prayuktyā 10

See notes in Tr. of 9.

tathā dharāpīha sumeruviddhā bhramaṇa pūrvāparam eva yāti
apāgudakkrāntivaśena yātā tv alakṣitā brahmagatir mahī syāt 11

-vaśena: -vasena *MS*.

vadanti ye bhūr acalā sugolā dharopari syāj jalagolam eva

mate ca teṣāṃ jalam ekadeśe sthitam na cādhaḥ patitam kuśaktyā 12

kṣitir jalānām kṣitikhātamadhye na golapiṇḍopari kutra drṣṭā
yadā kugolopari veṣṭitam kaṃ vimanyase no vahatīha kiṃ vā 13

bhūgolapiṇḍopari vārigolo no vārigolopari bhūmipiṇḍaḥ
svādhāramūle varuṇasthitih syād bhūkendraśaktyā tv api ko na doṣaḥ 14

-śaktyā: -śaktya *MS*.

udagyamāśākṣitisambhrameṇa tv apāgudaggolaphalasya siddhiḥ
suśītagharmartuvahasya madhye yataḥ pṛthivyām kiraṇāgram eti 15

-artu-: -ārtu- *MS*.

udagbhrameṇopari meruśīrṣe gataṃ yadā sūryamayūkhatejaḥ
tadā himānī draviṇasvarūpā gatā jale 'trāpi na kutra drṣṭā 16

ato himānīkṣaraṇād dhi śītam na jāyate bhūmitale sugole
himācalasyātha samīpadeśe tuṣārajīrṇaṃ laghu cāsti śukre 17

himācalād dūratare pradeśe bhavanti ye dākṣiṇagās ca deśāḥ
tuṣāranāśaṃ kṣaraṇād dhimānyā nidāghadāhena janā mriyante 18

nidāghadāhārtavighātakārtham kṛtā ca yāmye yamadūtikeyam
tayā sujīvanti narās ca sarve suśītalās chātra vareśvareṇa 19

suśītalās: śuśītalā *MS*.

apāk pṛthivyā bhramaṇena śītam prajāyate bhūmitale samaste
girau himānīpracayāc ca hetoḥ pramāṇadaṇḍe ubhayatra drṣṭe 20

apāk: apāg *MS*; prajāyate: prajñāyate *MS*.

samīpadūrasthavaśād dhimādrer analpam alpam ca bhavet tuṣāram
samastakhaṇḍeṣu yataḥ samīpe himādhikaṃ yāti himācalasya 21

-vaśād: -vasād *MS*.

himādhikatvena janāḥ samastā mṛtās tu tasmiṃ chakale vasantaḥ
sujīvitās cāgnisutāpanena prahrṣṭapuṣṭāḥ kila bhuktamāmsāḥ 22

calena bhūmau ghaṭate hi sarvaṃ tv ataś caloktā pṛthivī mayā ca
na manyase tvam yadi suṣṭhuyuktim jalādi sarvaṃ pratipādanīyam 23

23: *MS* numbers this as 22 as well, and then all following vss. in the *MS* are numbered incorrectly in turn, off by one.

yaḥ syāt pradeśaś calabhūmikāyā usrābhimukhyāt sa udeti tasyāḥ
so 'pi bhrameṇātra tv adhaḥ prayātītthaṃ jāyate vāsaravarddhanam hi 24

usrābhimukhyāt: rusrābhimukhyāt *MS*.

iti calābhūpratipādikāni ślokāni

calābhū: calaram bhūḥ *MS*.

ākṛṣṭīśaktiś ca kṣitau dvitīyā tv ākarṣaṇeṇoparigaṃ ca viśvaṃ
nāpaiti khe 'dho vahatī yatī sā śaktidvayena pratipāditā yā 25

śaktidvaye 'smin mahatī sukṛṣṭā lākṣādhikā kendragatā dharāyāḥ
nātaś calā bhāti mahī sugolā nīrabhrameṇāpy anumīyate sā 26

lākṣādhikāḥ: lākṣādhikā *MS*. nīrabhrameṇāpy: nīrarabhrameṇāpy *MS*.

pratyakṣayuktyā pratipāditam yat taj jyotiṣam śāstram api prasiddham
pratyakṣarūpaṃ paramam ca yasya candrārkabimbau kila sāksīṇau staḥ 27

ataḥ suyuktyā pratipāditā bhūr bhagolagolāntaragā calā sā
caturdaśaughair bhavanaiś citā ca svaśaktito vai viyati sthitā syāt 28

dharā nadīnām atha parvatānām tathā janānām paśupakṣīnām ca
bhaved adhiṣṭhātry avanīha loke citā samastāvayaveṣu taiḥ sā 29

avanī: avinī *MS*.

yathā ca loke kaṭahalphalam syāt sakaṇṭakam koṭīcitam tathaiva
rasā tṛṇair vā viṭapaiś ca nīraiś citā samastair dharaṇī praśastā 30

dharaṇī: dhariṇī *MS*.

laṅkā kumadhye yamakotir asyāḥ prāk paścime romakapattanam ca
adhas tataḥ siddhapuram sumerūḥ saumye 'tha yāmye vaḍavānalaś ca 31

kuvṛttapādāntarītāni tāni sthānāni ṣaḍ gola[vido] vadanti
vasanti merau surasiddhasaṃghāḥ aurve ca sarve narakāḥ sadaityāḥ 32

golavido vadanti : golavidanti, corrected to golavadanti *MS.* aurve: aurvye *MS. ŚŚB*
reads golavido vadanti.

yo yatra tiṣṭhaty avanītalastham ātmānam asyā upari sthitam ca
sa manyate 'taḥ kucaturthasaṃsthā mithas ca te tiryag ivāmananti 33

adhaṣīraskāḥ kudalāntarasthā chāyāmanuṣyā iva nīratīre
anākulās tiryagadhaṣsthitās ca tiṣṭhanti te tatra vyaṃ yathātra 34

dharābhraṃeṇoparinīcasamsthā janās tathā pārśvavibhāgagās ca
udakkayāmyetaragā rasāyā bhraṃam vinā nīcapadasya bhaṅgaḥ

udakka: udacka *MS.* See notes in Tr.

svārasyakam tiryagadhaṣsthitānām bhāṣyoktalālyavatām padānām
nāyāti bhūmibhramam antareṇa lokā yato bhūmyupari sthitāḥ syuḥ 36

sarvāsu dikṣu bhramabhūmikāyās tv ākāśarūpaṃ bhavatīha tulyam
ko 'dhaḥ kva cordhvo dharaṇīvibhāgo bhāṣyoktibhaṅgāc calabhūś ca kalpyā 37

dharaṇī: dhariṇī *MS.*

viśvaṃbharāyā bhraṃaṇena yasyās tv astodayam yāti divākaro 'hi
bradhnasthitir viṣṇupadasya madhye tam bhāskaram naumi sadoditam khe 38

iti nirādhārabhūpratipādikāni ślokāni

bhagolamadhye bhavatīha sūryo dvigolakendrāntaragā mahī syāt
khagolamadhye na rasā calatvād bhagolago bhāskara eva nānyā 39

ākāśagolasya bhaved bhagolaṃ kendre yatas tigmaruciḥ khakendre
na syād dharā madhyagatā calatvāt tatkendratā golabhagolakṣptā 40

sthire bhagole sthiraśūryabimbam janās ca paśyanti nīśāntaram tam
kugolapiṇḍabhraṃaṇād dhi hetoḥ kupṛṣṭhanīcoccagatā narās te 41

svabhūmipṛṣṭhasthitadrṣṭicihne kujaṃ vidheyam dharaṇītale 'smin
kuje 'rkabimbam yadi paśyatīha tadodayam vetti subhāskarasya 42

dharaṇī: dhariṇī *MS.*

svasthaṃ sthiraṃ bhāti calaṃ pratīcyāṃ prāgbhūbhramatvāc ca sadā janānām
brahmā yataḥ paśyati sṛṣṭikālād ārabhya kalpāntanirantaraṃ tam 43

dharāgatir no bṛhatī yataḥ [syāt] pratīyate sā na vipaścitanām
yathā supotasya janasya bhāti gatir na potasya gṛhasthitasya 44

syāt: conjecture for lacuna of one heavy syllable in text.

jalabhrameṇāpy anumīyate 'sau jalāni sarvāṅy api prāk prayānti
gatir yataḥ syān mahatī ca teṣāṃ pratīyate sākḥilabālakānām 45

prāk: prāg *MS*.

yeṣāṃ gatiḥ paścimamārgagā ca sā [vai] jalādhikyavaśād bhavec ca
sadyo nadīnām nabhasi kṣaṇe syāt tīrasya pārśve viparītavegaḥ 46

vai: conjecture for lacuna of one syllable in text. vaśād: vaśād *MS*.

pūrvapradeśaṃ namitaṃ yadā [syā]t tasyāḥ parasthaṃ ca jalaṃ tv apaiti
ākaraṇatvād dravavāriḡolo nāpaiti khe 'dho vahati svagatyā 47

syāt: conjecture for lacuna of one syllable in text.

svasthaṃ sthiraṃ bhāti calaṃ pratīcyāṃ prāgbhūbhramatvāc ca sadā janānām
brahmā yataḥ paśyati sṛṣṭikālād ārabhya kalpāntanirantaraṃ tam 48

Note: same vs. as 43. See notes in Tr.

atha khaṇḍanaṃ

ye 'nye vadanty asthirabhāskaraṃ hi kalpātmakaṃ brahmadinaṃ ca teṣāṃ
pakṣe 'dhunā kutra divākarasya sthitir vada jñānaprabodhakasya 49

kutra sthitir brahmapitāmahasya bhūgolagolopari darśaya tvam
merūrdhvadeśopari ye vasantas teṣāṃ ca ṣaṇmāsadinam bhavec ca 50

bhū-: in margin, *MS*.

jñātaṃ mayā ye pravāsanti khe 'dhas teṣāṃ apīhāyanavāsaraṃ ca
pṛthvīpradeśeṣu samastakeṣu nānyeṣu ṣaṇmāsadinam bhavec ca 51

pitāmahasyātha [ca] vāsarasya gataṃ ca sārddhapraharaṃ yathā vā

calena sūryaḥ kṣitijorddhvam eti nṛṇām kathaṃ syān na viparyayatvaṃ 52

-ātha ca: conjecture for-ātha, with missing syllable in text. vāsarasya: -sa- in margin,
MS. viparyayatvaṃ: viparyyatvaṃ MS.

śṛṅgonnatau vā caturānasya sthānaṃ vadanty abhagr̥he viram̐ceḥ
merūnnater vāsaramānam abdaṃ labdhaṃ na kutrāpi ca kalpatulyaṃ 53

madīyapakṣe parameṣṭhinaś ca bhūgolagolopari veṣṭitasya
brahmaikatattvasya pitāmahasya namāmy ahaṃ vyaktasanātanaṃ taṃ 54

parameṣṭhinaś: parimeṣṭhinaś MS. veṣṭitasya: veṣṭhitasya MS.

padmātmakām ye pravadanti pṛthvīm teṣāṃ mate vāryupari sthitā bhūḥ
sthānaṃ ca kasyopari vāriṇaś ca tv ādhārasūnyena na kutra lekhaḥ 55

vāryupari: vāyyupari MS. 55: omits MS.

iti śrīlajjāśaṅkarachātrāgovindakṛtaṃ bhūmibhramaṇaṃ samāptaṃ

III. Translation

Reverence to Lord Gaṇeśa.

1 I bow down to the feet of the great Lord (Śiva) and of the shining Goddess (Pārvatī). Ever finding refuge in Gaṇeśa and Speech (Sarasvatī), and having taken up dust from the feet of my teacher, I shall expound a text on the revolution of the earth, according to [my] ability.

The name of his teacher, Lajjāśaṅkara, is given in the colophon.

2 I have compiled it with original arguments; [I have] fashioned it in fifty-nine well-reasoned Upendravajrā and Indravajrā verses. The verses are easy to understand, and go beyond the view of the Purāṇas.

“fifty-nine verses:” see notes to vs. 4. Upendravajrā and Indravajrā are types of Triṣṭubh verses. The verse patterns differ only in that the Indravajrā begins with a heavy syllable, the Upendravajrā a light one. “go beyond the view of the Purāṇas” (*purāṇabāhya*) - see the Introduction on Wilkinson and the Sihore school.

3 Why has the moving [earth] not been declared to be moving in the [traditional] science by the good reasoning of those who know how to express the truth of discrimination? I shall declare in [this text,] the Revolution of the Earth, that the earth is a sphere as demonstrated by that reasoning.

Govinda indicates that Jyotiḥśāstra can be made to incorporate the heliocentric view. “how to express the truth of discrimination:” i.e. in Sanskrit.

4 I shall show [that the earth] is a sphere in four verses; [that the earth is] mobile in sixteen original, easy-to-understand [verses.] With fifteen verses [I shall show that the earth] is in space [and is not fixed on some other basis.] With the rest of the verses [I shall show that the earth] is not at the center [of the cosmos.]

Verse 2 states that there will be fifty-nine verses. Aside from the four in the Introduction, there are, in the extant manuscript, four in section A, sixteen in section B, fourteen in C, ten in D, (with a repeated verse) and seven in E. Including the repeated verse, this sums to 55, so there are at least four verses, and possibly a fifth, missing. By reference to Govinda's statement in this verse, we can conclude that one verse must be missing from section C. The other verses are missing either from section D, or most probably from the end of E, where the text breaks off abruptly. There is no conclusion or summary given to match the introduction.

A. The Earth is a Sphere

5 A person [standing] in the region of the equator sees the two pole stars, northern and southern, in contact with the horizon. If he goes north from the equator, he sees the north pole star rise above the earth.

The argument is Bhāskara's - *SŚB Bhuvanakośa* vss. 48-50. Here Govinda begins to make good on his promise in vs. 3 of using Siddhāntic reasoning.

6 I have asserted that the earth is spherical. The wise should always consider it so. Because one hundredth of the circumference appears flat, for that reason the [whole] earth is thought to be flat, O pupil, [though in fact it is not.]

“a hundredth:” i.e. the small fraction of the earth's surface that one can see from any given point on its surface. The argument is again Bhāskara's - *SŚB Bhuvanakośa* vs. 13.

7 Those who say the earth is flat are ignorant; they have no understanding of the increase in the elevation of the pole star. Since there is some (change in

polar star elevation) everywhere on earth, the earth is not flat; [this] they ought to propound, therefore.

8 The earth could not be flat, either in past, present, or future. The earth, with its beautiful regions, was fashioned as round. Just as the sesame seed of our ordinary experience is round, so is [the earth] round on all sides.

He argues against an explanation by appeal to different ages. This explanation was sometimes circulated in order to reconcile Purāṇas and Siddhāntas, to the effect that the earth was of the shape described in the Purāṇas in previous ages, but of the shape described by the astronomers now. See Minkowski, "Competing Cosmologies in Early Modern Indian Astronomy," *Fs. Pingree*, pp.349-85.

So end the verses that expound the earth's spherical shape.

B. The Earth Moves

9 There is a force that pervades the moving earth; nevertheless the earth does not go downward, nor does it go upward. Rather, it goes [around] like a polished bead, [and also moves] according to the north-south declination.

The point is that the sun does not move; the earth does. There are two motions involved, daily and annual, as will be explained. *mahrerukaṃ* is not a Sanskrit word. As the next verse makes clear, it must refer to an artifact of material culture with a non-Sanskrit name. The context shows that it is something worn by women, and is a small sphere or ball which is pierced and has a shaft through its center on which it spins. It appears therefore to be some sort of bead on an earring or necklace. An approximately similar word in the Persian/Urdu context is *muhra* or *muhraḳa*, a polished bead. The c pāda might be hypermetric because the term introduced is not Sanskrit. *apāgudak* - Going on its annual declination circle, thus moving above and below the plane of the sun.

10 In the common [speech] the round bead [worn by] women with beautiful eyes and charming limbs is referred to as a "mahreru." Pierced [through the center] by a shaft, its motion carries it with an energy east-west.

11 The case is the same for earth - pierced by Meru it goes with a rotation east-west. And though it [also] moves according to a north-south declination, since the earth has the stately pace of Brahmā, its motion is not noticed.

12 Those who say the earth is a sphere that does not move, [for them] the waters must keep to their own sphere that is atop the earth; and according to their view the water should stay in one place, and cannot fall downward, driven by the

earth's force.

a describes the Siddhāntic view, (also the Ptolemaic view, which would have been current in India in Islamicate forms, and also retained in part in some of the European cosmology that Govinda knew, such as in Bacon's.) Already in Aristotle the movement of the waters downward was explained, but apparently Govinda thinks that there has been no adequate explanation of the movement of the waters on earth in the fixed-earth model. In this he agrees with Galileo, whose work he would have known something of, at least through references in the *Novum Organum*. Galileo thought that the static Ptolemaic earth-model did not explain tidal motion - *Dialogue* 484. Govinda makes the movement of waters an important part of his own argument. See below and the Introduction.

13 [Still others might say that] the reservoir of the waters is in the middle of an excavation in the earth [and that] it is nowhere seen on top of the earth. [But we reply that] when water is seen to encircle the earth above it, do you not contradict yourself, or [do you accept that] the waters flow here?

kaṃ: water. Again the tidal movement of waters around the earth's surface is highlighted. The idea of cavities in the earth filled with water is reminiscent of the legend of the sons of Sagara, and more distantly of Aristotle's *Meteorologica* I.13.

14 The water sphere is over the earth sphere; it is not the case that the earth sphere is over the water sphere. [If it were, then] the abode of Varuṇa would have to be based on its own support. But when [we accept that] the earth [is the basis,] through the force of earth's gravity there is no such problem.

This is a rejection of a Purāṇic view that the earth rests on water; the view was also attributed to Thales, and the doxography of cosmologies transmitted by Muslim scientists did sometimes report the view.

15 By [assuming] the motion of the earth to the north and south of the plane of the Sun, the [same] result is achieved as by [assuming that] the [motion of the sun] south and north in its sphere is the cause of the cold and hot seasons, since the strongest ray strikes the earth at its midpoint.

The sense of the following verses (15-23) is that it is the earth's annual movement that causes the change in seasons, which movement has been incorrectly attributed to the sun. d appears to be a reference to the sun's position on the equator at the beginning point of the cycle described in vss. 16-23, or perhaps it is a round-about way of saying that the sun's heat is increased when it strikes a region of the earth more directly.

16 With the [motion of the earth that causes the sun’s apparent annual] northward motion, when the heat of the sun’s ray goes over the head of Meru, then no one sees the mass of snow which has become fluid in nature and has turned into water.

Or we could translate *udagbhrameṇa* more directly as “with the earth’s motion north,” but this would not reflect the sense or the physics intended here.

17 Then, because of the melting of the snowmass, cold does not arise on the spherical earth’s surface. In the vicinity of the Himālayas the frost diminishes and becomes scant in the month of Jyeṣṭha.

śukra- taken here to be the name of the lunar month Jyeṣṭha, which falls in May/June, the hottest season in India. *tuṣārajīrṇam*: understand *tuṣāraṇ jīrṇaṇ*.

18 For those countries that are far from the Himālayas and in the southern reaches, there is a loss of frost due to the melting of the snowmass, and people are [as if] dying because of the heat of the summer.

19 The Tamarind tree was created to remove the suffering caused by the heat of the summer season in the South. Through this [tree] all men live well, staying cool, O pupil, through the [grace of Śiva,] the granter of wishes.

Alternative reading without emending the text: *susītālāchātra*, “O disciple (i.e. worshipper) of Śītālā.” Tamarind is used to make foods that are “cooling.”

20 When the earth moves [to cause the apparent motion of the sun to the] southward, then cold arises on the whole earth’s surface, caused by the accumulation of the snowmass in the mountains. Two standards of measure are seen in both places:

The two standards are given in vs. 21: close or far.

21 Depending on whether [a place] is close or far away from the Himālayas there is more or less frost, since a lot of snow reaches into all the areas in the region of the Himālayas.

22 All people who dwell in that part are [as if] perishing because of the abundance of snow there, but they are revived by the heat of fires and are delighted and nourished when they eat meat.

23 Everything therefore makes sense through [assuming] motion on the part of the earth. Therefore I have stated that the earth moves. If you do not think this is

good reasoning, then you must explain everything, beginning with the problem of water, [some other way.]

"problem of water:" a reference to verse 12 above.

24 Whatever might be the region of the revolving earth, when it is facing toward the sun, that [part] of [the earth] "rises." Through the [daily] revolution, it also "sets." In this way arises the dividing of the day [in the course of the year.]

The latitude of the earth that faces the sun is what we (inaccurately) refer to as the sun's point of rising and setting.

So end the verses proving the earth revolves [around the sun].

C. The Earth has No Support

25 There is a second [force] in the earth, a force of attraction. Through this attraction everything stays atop the earth [and] does not fly away into space. It [the earth] goes, holding things down, [the earth] which has been explained according to its pair of forces.

26 Of these two forces, the greater is the attractive force directed to the center of the earth, greater even [in holding power] than (sticky) resin. Because of this [second force], the globe does not appear to rotate, but it can be inferred [to do so] because of the circling motion of the waters.

c: everything is carried along with the earth and moves at the same speed. *lākṣādhikā* - lit. "greater than lac/lacquer." One could alternatively read *lakṣādhikā*, and understand "greater than a hundred thousand," but there is no specification of what. cd: again, the tidal motion of earth's waters is Govinda's chief proof of the earth's motion. Other verses about waters on the surface of the earth are: 12-14, 23, 44-47, 55.

27 That which has been explained through appeal to empirical evidence is also well known from the Jyotiḥśāstra, and the highest form of empirical confirmation of this [Jyotiḥśāstra] is the evidence provided by the disks of the sun and moon.

Apparently a reference to the prediction of eclipses by Jyotiḥśāstra, the correctness or incorrectness of which predictions can be seen by anyone. Furthermore, since one can see the shadow of the earth in the lunar eclipse, one might expect to see the shadow of the earth's support as well, if there were any.

28 Thus the earth has been shown, with good arguments, to move among the

spheres of the celestial sphere. It is covered by fourteen oceans and continents. It has its place in the sky by its own power.

c. seven oceans and seven continents *SŚB Bhuvanakośa* 21-42. d. i.e. it is not held up or supported by some other object. Compare *SŚB Bhuvanakośa* 2.

29 The stable earth is the supporter here of the rivers, mountains, people, beasts, and birds. She is covered entirely by these in all her parts.

Compare *SŚB Bhuvanakośa* 3

30 Just as in common experience the jackfruit has thorns and is covered with sharp points, or just as a river is covered by waters and grasses and shoots, in the same way the earth is known to be covered by all things.

Compare *SŚB Bhuvanakośa* 3, where the comparison is to a Kadamba flower.

31 [As Bhāskara said:] “Lañkā is at the middle of the earth’s [surface]. To the east of Lañkā is Yamakoṭi, and to the west is Rome. Below is Siddhapura. To the north is Meru and to the south the submarine fire.

vss. 31-34 are cited verbatim from *SŚB Bhuvanakośa* 17-20. Siddhapura is 180° from Lañkā on the equator.

32 “Those who know the globe say that these six places are separated [from one another] by a quadrant of a great circle of the earth. The hosts of gods and Siddhas live on Meru, and all the demons and the Daityas in the submarine fire.

33 “Whoever stands at any point [on the earth] considers himself to be standing on the earth’s surface and located on top of it. Hence those located at a distance of a quarter [of a great circle] of the earth from each other, consider each other to be standing sideways.

34 “Those standing halfway around the earth are head-downward, like the reflection-men we see standing on the bank of a river. Yet those standing [from our perspective] sideways and downwards, are as untroubled as we are standing here.”

35 Through the revolution of the earth people are positioned on top, then below, and also on the two sides, except for those who are at the North and South [poles]. If we do not suppose the rotation of the earth, there would be the error of a [permanently] lower side.

udakkayāmyetaragā is not a very satisfactory solution to the problematic reading in the *MS*. Given the *MS*'s treatment of ligatures, the reading could be *udak ca yāmyetaragā*, though this whole phrase would have to be understood as an irregular compound. Vss. 35-37 constitute a connected argument which is closely tied to the wording of a "Bhāṣya." Unfortunately the identity of this *Bhāṣya* has not been determined. The likeliest candidate is Bhāskara's autocommentary on the *Siddhāntaśiromaṇi*, though no obvious passage recommends itself. (Other works widely known as the *Bhāṣya* are Patañjali's *Mahābhāṣya* and Śāṅkara's *Brahmasūtrabhāṣya*, but neither of these contains an argument of the sort indicated here.) The general sense, however, is clear, that there is an authoritative text that describes a variety of people in the different parts of the world, and that this variety implies (for Govinda) a rotation of the earth. d could also be construed: "there would be contradiction of the *Bhāṣya*'s term 'nīca-.'"

36 Without the revolution of the earth there would be no variety in the places located sideways and below, whose charming [properties] are described in the *Bhāṣya*, for [all] regions would [then] be positioned on top.

Govinda appears to find an implication in the *Bhāṣya* that without rotation, people could only live on the top part of the earth, and hence the charming variety of peoples and regions would be lost.

37 The shape of space is the same in all directions for the revolving earth. Which part of the earth could be low, which high ? Because there would also be a contradiction of the statement of the *Bhāṣya*, the earth must be supposed to be in motion.

38 The sun appears to set and rise because of the rotation of the earth. The sun is situated in the center of the highest heaven (*viṣṇupada*). I do homage to that light-maker (the sun), who is always raised in the sky.

d. i.e. the sun does not rise or set. *bhāskara* is a play on words with the name of the author Bhāskara, whose *Siddhāntaśiromaṇi* and perhaps auto-commentary have been cited and appealed to in this section. vss. 37d and 38a are linked grammatically: "due to the rotation of which earth..."

So end the verses proving that the earth is without support.

D. The Earth is Not at the Center

39 The sun is in the center of the starry sphere. The earth must be someplace other than at the center of the two spheres. [The earth] is not at the center of the sphere of space because of its movement. The sun is in [the center of] the starry

sphere, not the other [i.e. the earth is not at the center.]

The “two spheres” are the starry sphere (*bhagola*), and the sphere of space (*khagola*). Both are useful holdovers from the geocentric, Siddhāntic and Ptolemaic model. d. would make more sense reading *khagolago* - “the sun is [also] at the center of the sphere of space.”

40 The starry sphere must be concentric with the sphere of space, because the sun is at the center of space. The earth cannot be at the center of space because it moves. In this way we imagine the concentric nature of the sphere of stars and of space.

41 The starry sphere is fixed, and the globe of the sun is fixed. Yet people see [the sun rising] after intervals of night. This is because of the rotation of the earth’s massive sphere, for people are [successively] on the lower and [then] upper side of the earth.

See above, vss. 35-37.

42 The horizon is established in relation to the earth’s surface by reference to the line of sight of a [person] from his own position on the earth. When one sees the disk of the sun on the horizon, one knows that that is the moment of sunrise.

The verse offers perhaps an explanation of differences in local sunrise: not caused by the sun’s motion, but by the rotation of the local horizon into contact with the sun.

43 Because of the rotation of the earth to the east, [the disk of the sun,] though solid and stable, always appears to people [on earth] to be moving west. Since Brahmā sees [the sun] steadily from the start of creation, he sees it without interval to the end of the kalpa.

This verse is repeated below at 48. The first half makes sense here; the second half makes sense below. There has been, perhaps, a conflation of two verse halves, and the other halves are missing. The verse will be retained below as well, therefore.

44 Since the motion of the earth is not great, it is not perceived [even] by the perspicacious, just as the motion of a boat tethered to the shore is not apparent to a person aboard an [unmoored] boat.

It is difficult to make the analogy work. It must be about the unnoticeable speed of the earth’s rotation. Compare *Āryabhadṭīya*, *Golapāda* vs. 9. The point must be that a

person floating in a slow-moving current will not feel himself moving.

45 Through the circling of the waters, too, [the movement of the earth] can be inferred. All waters flow eastward. Since their movement is large, it is perceived by every child.

This verse and the following two constitute Govinda's appeal to tidal motions as a proof of the earth's motion, in which he is inspired by Bacon's argument in the *Novum Organum* and the reference there to Galileo's theory that the motion of the spinning earth is the cause of the tides - *NO* 2.36 and 2.46 respectively. See the Introduction, and above, vss. 12-13 and 26. According to this view, the earth's rotation is the cause of the tides, the basic evidence of which is the observable general tendency of waters to flow eastward.

46 The movement of those waters that flow westward is caused by the excess of waters. Otherwise [the waters] of rivers would suddenly be in the heavens, in an instant. [Instead] there is a reverse flow that begins on the edge of the shore.

The verse is very compressed, suffers from a lacuna, has ambiguous antecedents and an abundance of (probably otiose) *ca*'s. The argument follows one of Bacon's, again, about currents of water, and the equilibrium of the flow of water - *NO* 2.36, and at greater length in his "De fluxu et refluxu maris." The movement of waters that do not follow the prevailing eastward direction is explained in this way, and continues in vs. 47.

47 When its [earth's] [water] has been made to flow to the eastern region, then the higher water [accumulated there] flows away to the [west]. Because of the effect of attraction, the fluid sphere of water does not fall away into the air; [rather] it stays down and flows by its own movement.

The waters, upon flowing east onto a shore, are then reflected back, and hence the tides rise and fall. Again, Govinda is here inspired by Bacon's reference to Galileo's argument - *NO* 2.46.

48 Because of the rotation of the earth to the east, [the disk of the sun,] though solid and stable, always appears to people [on earth] to be moving west. Since Brahmā sees [the sun] steadily from the start of creation, he sees it without interval to the end of the kalpa.

See notes to the translation of vs. 43.

E. Now the Critique [of Other Positions]

49 [You] who say that the sun moves, and yet accept that a day of Brahmā consists of a kalpa, you should say where in your view do you now place the sun, the awakener of [our] understanding ?

It is a basic doctrine of the Purāṇic model that the day of Brahmā lasts for an entire kalpa: a thousand eons, the duration of any one creation. The author does not doubt this view (see verse 43cd/48 cd). He will now proceed to show that the old geocentric model cannot be reconciled with the Purāṇic one, by rejecting a series of possible explanations of Brahmā's position in the cosmos. "awakener of our understanding:" an allusion to the Gāyatrī verse recited by all observant Brahmins.

50 And they should show where is the place of Brahmā, the grandsire, [who, I maintain, is] above the sphere of the spheres of the earth. Those [gods] living atop Meru [at the pole] have a day that lasts [only] a half-year, [and not an entire kalpa.]

One possible place where Brahmā could be located is in the heavenly world atop Mt. Meru, which, in the Siddhāntic model, has become the earth's axis, with a bit projecting above the north pole. Seen from the north pole, the sun is above the horizon, (because above the celestial equator,) for half a year, and hence the day lasts for half a year there.

51 I know that those who live in the space below, [i.e. atop the south pole,] also have a day that lasts for a half-year. But a day lasting for six months is not found in any other region of the earth.

The longest "day" on earth is at the poles, and that is only six months in length, far short of a kalpa. So Brahmā cannot be located anywhere on earth.

52 And as for [those who argue that] a watch and a half of the "day" passes before the sun rises for Brahmā in the same way that through its motion the sun rises above the earth's horizon for men [only after a watch and a half of the day has passed,] how could this viewpoint also not be contradictory?

Argument unclear, but perhaps this: If one were to define a "day" of Brahmā as a nychthemeron, i.e. including both a day and a night, and if one were to assume that such a "day" began at midnight, then one could argue that the sun need not be seen by Brahmā for the entire "day," the sunlit part of the day beginning only a watch and a half (= 3/16ths of the day) after the day began. In this way, one might hope to rescue the idea that the day of Brahmā could be longer than six months, even if Brahmā cannot see the sun the whole time. In the Saurapakṣa there is, furthermore, an initial period of the Mahāyuga posited during which the planets stay motionless in their starting positions before beginning to revolve. This period is one and a half times the duration

of a Kaliyuga, so perhaps Govinda derives his one and a half watches from this idea, and the possibility of darkness being included in the day. But as he points out, these assumptions violate the definitions they are designed to save.

53 Or else [there are some] who say that the four-faced Brahmā's place is on a peak of the [Meru] mountain, in a residence in the sky. From the elevation of Meru one could then obtain a day length that lasted for a year. [Still,] this is in no way comparable to the duration of a kalpa.

The term *śṛṅgonnati* brings to mind the astronomical term for the calculation of the elevation of the horn of the crescent moon. But it is difficult to make sense of this, since if one were to assume that Brahmā dwelled on the tip of the moon's crescent, there would be no astronomical phenomenon that would enable Brahmā to see the sun without interruption for an entire year. The possible explanation, reflected in the translation is as follows: let us assume instead the Purāṇic flat earth, tall Meru model. Atop Meru are three peaks, on one of which dwells Brahmā. [*SŚB Bhuvanakośa* vs. 36] Perhaps at its southernmost "declination," the sun is obscured on one day of the year by one of the other peaks. Thus night occurs only once a year atop Meru, and in this way one would get a day-length of a year for Brahmā. Still, argues Govinda, this is nothing near the length of a kalpa.

54 In my view [the place] of Brahmā, the highest Lord, the grandsire, who is of the same reality as Brahman, who encircles the world, is above the sphere of spheres of the earth. I bow down to him who is eternally manifested.

The missing noun for "place" could be supplied by reading *parimā + iṣṭhinaḥ*, "the size of the powerful...". This reading is supported by the MS, but the two nouns are both rare usages. Compare the empyrean location of the deity in the Christian version of the Ptolemaic model.

55 Those who say that the earth is in the form of a lotus, in their view the earth rests on top of water. But the resting place of water is then on top of what? Because of the absence of support, they have written nothing about this.

Compare *SŚB Bhuvanakośa* vs. 8 . See vs. 14 above.

So ends the Revolution of the Earth by Govinda, the pupil of the eminent Lajjāśaṅkara.

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