

# Calculation of True Daily Motion

## Two Rules of the *Brāhmasphuṭasiddhānta*

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### Abstract

Brahmagupta, an Indian astronomer flourished in early 7th century, gives two rules for computing the true daily motion of the planets in his *Brāhmasphuṭasiddhānta* (BSS), chapter II, 41–42ab and 42cd–44. In this paper, I newly edited these parts using five manuscripts with the well known but not edited commentary composed by Pṛthūdakaśvāmin who flourished in the 9th century, translated them into English, and gave mathematical commentaries.

### Abbreviation for Astronomical Works

- PS: *Pañcasiddhāntikā* of Varāhamihira (composed ca. 550)  
BSS: *Brāhmasphuṭasiddhānta* of Brahmagupta (composed 628)  
MBh: *Mahābhāskarīya* of Bhāskara I (composed before 629)  
LBh: *Laghubhāskarīya* of Bhāskara I (composed after MBh?)  
KhKh: *Khaṇḍakhādyaaka* of Brahmagupta (epoch 665)  
SDV: *Śiṣyadhivṛddhidatantra* of Lalla (composed ca. 750?)  
SS: *Sūryasiddhānta* (composed ca. 800)  
VS: *Vaṭeśvarasiddhānta* of Vaṭeśvara (composed 904)  
SSI: *Siddhāntaśiromaṇi* of Bhāskara II (composed 1150)  
SSE: *Siddhāntaśekhara* of Śrīpati (composed ca. 1050)

## I Introduction

### I.1 Brahmagupta

Brahmagupta, the son of Jiṣṇugupta, composed two astronomical books:

1. The *Brāhmasphuṭasiddhānta*; according to verses 7 and 8 of chapter XXIV, Brahmagupta composed this comprehensive astronomical treatise at the age of thirty in Śaka 550≈A.D. 628 during the reign of King Vyāghramukha of the Cāpavaṃśa.
2. The *Khaṇḍakhādyaaka*; a *karāṇa*, practical manual which gives pragmatic rules for astronomical computations, whose epoch is Śaka 587≈A.D. 665 (KhKh I, 3).

He was called Bhillamālavakācārya by Pṛthūdakasvāmin and by Utpala, who borrowed many phrases from Pṛthūdaka's commentary, in their commentaries on the *Khaṇḍakhādya*.

## I.2 Pṛthūdakasvāmin

Caturveda Pṛthūdakasvāmin, the son of Madhusūdana Bhaṭṭa wrote commentaries on the two works of Brahmagupta, the *Brāhmasphuṭasiddhānta* and the *Khaṇḍakhādya*. He refers to Śaka 786≈A.D. 864 and Kurukṣetra in his examples (udāharaṇas) in the commentary on the *Khaṇḍakhādya*. He also uses the solar eclipse on 4 March 862 in the commentary on KhKh V, 1–2. He refers to Kānyakubja and Sthāṇvīśvara in his commentary on BSS XXI, 10 but these references seems to come from the lost commentary of Balabhadra.

## I.3 *Brāhmasphuṭasiddhānta*

The *Brāhmasphuṭasiddhānta* is a comprehensive astronomical treatise consisting of 25 chapters.

Commentaries on this book were written by Balabhadra and Pṛthūdakasvāmin. Balabhadra's commentary is lost and only some verses quoted by Pṛthūdakasvāmin and Utpala and some passages in Arabic by al-Bīrūnī are known. There is also an anonymous commentary on the first ten chapters (*Daśādhyāyī*), and another on the kuṭṭakādhyāya.

An edition of the *Brāhmasphuṭasiddhānta* with Pṛthūdaka's commentary is in progress by the present author and its first part (chapter XXI) is going to be published as supplements of *Indian Journal of History of Science* in March 2003. This part of the edition will be included in my future edition of the whole chapter II.

There are other three editions of the *Brāhmasphuṭasiddhānta*: one by Sudhākara Dvivedin (Dvivedin 1902) and two by Ram Swarup Sharma (Sharma 1966 and 1968). Let us compare their text of BSS II, 41–44:

Dvivedin's edition (Dvivedin 1902, pp. 39–40) runs:

grahamandakendrabhuktir jyāntaraguṇitā "dya jīvayā 214 bhaktā |  
labdham sphuṭaparidhighnam bhagaṇāmsahrtaṃ kalābhis tu || 41  
mṛgakarkyādāv ūnādhikā svamadhyamagatiḥ sphuṭā 'rkendvoḥ |  
śīghragatiṃ mandaphalasphuṭabhuktyūnām kujādīnām || 42  
śīghraphalam bhogya jyāsaṅguṇitaṃ tv ādyajīvayā vibhajet |  
phalaguṇitaṃ vyāsārdham vibhājayet śīghrakarṇena || 43  
labdhonā śīghragatiḥ sphuṭabhuktir bhavati labdham adhikam cet |  
śīghragateḥ śīghragatiṃ labdhāt saṃśodhya vakragatiḥ || 44

Pingree's explanation in the *Dictionary of Scientific Biography* (Supplement I, p. 569) is based on this edition.

Sharma's 1966 edition (Sharma 1966, vol. II p. 210) is exactly the same as Dvivedin's

edition except:

41d: bhagaṇāṃśa360hr̥taṃ ('360' inserted)

43d: vibhājayec chīghra°(sandhi corrected).

Sharma's 1968 (Sharma 1968, pp. 37–39) edition reads:

grahakendrabhuktijyākaraḡuṇitādyajīvayā bhaktā 214 |  
 labdhaṃ sphuṭaparidhiḡuṇaṃ bhagaṇāṃśahr̥taṃ kalābhis tu || 41  
 mṛgakarkādyaḡ ūnādhikā svamadhyamagatiḡ sphuṭārkeṃdoḡ |  
 śīghragatimaṇḡdaphalasphuṭabhuttyunāṃ kujādinā || 42  
 śīghraphalaṃ bhogyajīvāḡuṇitā māghajīvayā vibhajet |  
 phalagūṇitaṃ vyāsārd̥dhaṃ vibhājayet śīghrakaraṇena || 43  
 labdhonāśīghragatisphuṭabhuktir labdham adhikaṃ cet |  
 śīghragateḡ śīghragatiḡ labdhā saṃśodhya vakragatiḡ || 44

This arbitrary edition does not make any sense.

P. C. Sengupta quotes II 41–44ab, not showing any sources, in his introduction added to the reprint of the English translation of the *Sūryasiddhānta* by E. Burgess (Gangooly 1935, pp. xxiii–xxiv). His quotation is similar to Dvivedin's edition but includes some differences:

41d: °hatam for hr̥tam

42b: °ārkeṃdoḡ for °ārkeṃdoḡ

43a: °phalabhogyā° for °phalaṃ bhogyā°

43b: °gūṇitāṃ for °gūṇitaṃ

43c: °ārd̥dhaṃ for °ārd̥dhaṃ.

The third and fourth differences are significant.

## I.4 Manuscripts

Manuscripts I used for the present edition are:

**I:** India Office Library Sanskrit 2769.

**P<sub>1</sub>:** Pingree 15. Copied in 1960 from VVRI Library no. 1781 by Shri Keshawanand (KN) and compared by Shri Dindayal (DY).

**P<sub>2</sub>:** Pingree 16. Copied in 1973 from ff. 1–226 of BORI 339 of 1879/80.

**R:** RORI Jodhpur 35182.

**V<sub>1</sub>:** Vārāṇasī, Sarasvatī Bhavana 98256. A copy of I.

All of them include both BSS verses and Pṛthūdakasvāmin's commentary. I also referred to Dvivedin's edition (D) for BSS verses and Sharma's 1966 edition (S) for Pṛthūdaka's commentary (Sharma 1966 pp. 210–212).

## I.5 Editorial Notes

The base passages (mūlas) of the *Brāhmasphuṭasiddhānta* on which Pṛthūdaka comments are printed in boldface. Quotations, including verses cited from elsewhere in

the *Brāhmasphuṭasiddhānta*, are printed in italic.

Pointed brackets (< >) enclose my additions; square brackets ([ ]) are used to delete word(s).

In addition to these, I used parentheses in the translation which enclose explanatory additions.

I entered almost all of the variants in the apparatus including errors of sandhi, but did not record changes caused by my insertion or deletion of daṇḍa or common changes of letters such as: v ⇔ b; ñ, ñ̄ ⇔ ṁ.

## II BSS II, 41–42ab

### II.1 Text

(IV<sub>1</sub> 65v l. 5; R 34r l. 8; P<sub>2</sub> p. 59 l. 13; P<sub>1</sub> p. 181 l. 9)

idānīm<sup>1</sup> sarvagrahāṇām bhukter mandaphalena<sup>2</sup> ᵇsphuṭikaraṇāyāryām<sup>3</sup>  
sārdhām<sup>4</sup> āha ||

grahamandakendrabhuktur<sup>5</sup>  
jyāntaragūṇitādyajīvayā<sup>6</sup> bhaktā<sup>7</sup> |  
labdham sphuṭaparidhiguṇam  
bhagaṇāmśahr̥tam<sup>8</sup> phalakalābhiḥ<sup>9</sup> || 41  
mṛgakarkyādāv ūnā-  
dhikā svamadhyamagatiḥ<sup>10</sup> sphuṭār̥kendvoḥ<sup>11</sup> | 42ab<sup>12</sup>

grahasya mandakarmani yat kendram<sup>13</sup> ᵇtad<sup>14</sup> grahamandakendram<sup>15</sup> | ta- S p. 210 l. -6  
sya **bhuktiḥ**<sup>16</sup> | yathā madhyagrahāt svamandoccam viśodhya kendram bhavaty  
evam<sup>17</sup> grahamadhyabhukteḥ<sup>18</sup> svamandoccabhuktim<sup>19</sup> viśodhya kendrabhuktur IV<sub>1</sub> 66r  
bhavati | s̄a ca<sup>20</sup> **jyāntaragūṇitā**<sup>21</sup> kāryā | aviśeṣamandakarmani<sup>22</sup> bhujajyāyām  
kriyamāṇāyām<sup>23</sup> yaj<sup>24</sup> jyāntaram abhavat<sup>25</sup> tena<sup>26</sup> guṇanīyety<sup>27</sup> arthaḥ | tata  
**ādyajīvayā bhaktā**<sup>28</sup> kāryā<sup>29</sup> | **ādyajīvā**<sup>30</sup> prathamam<sup>31</sup> jyārdham manuyamalā  
ity arthaḥ 214<sup>32</sup> | tato yal **labdham** tat ᵇ**sphuṭasvamandaparidhinā guṇitam**<sup>33</sup>

<sup>1</sup>ya is inserted after this by DY P<sub>1</sub> <sup>2</sup>palena I <sup>3</sup>āryā P<sub>1</sub> <sup>4</sup>between ᵇ and <: °karaṇāya  
sārdhām āryām RP<sub>2</sub> <sup>5</sup>°muktur IV<sub>1</sub>; °ktiḥ R; °kti P<sub>2</sub> <sup>6</sup>°jīvanāyā IV<sub>1</sub>; svām̄taragūṇitādyujīvayā  
RP<sub>2</sub>; °dyājīvayā P<sub>1</sub> <sup>7</sup>bhuktā RP<sub>2</sub>; bhaktāḥ P<sub>1</sub> <sup>8</sup>°hṛttam IV<sub>1</sub>; °hatam P<sub>2</sub> <sup>9</sup>phalam kalā° IV<sub>1</sub>  
<sup>10</sup>°gati IV<sub>1</sub>; svamadhyagati R; svayamadhyagati P<sub>2</sub> <sup>11</sup>°ṭākendroḥ R; °ṭākedvoḥ P<sub>2</sub> <sup>12</sup>om. this  
half verse P<sub>1</sub> <sup>13</sup>om. RP<sub>2</sub>; kendra P<sub>1</sub> <sup>14</sup>tat R <sup>15</sup>between ᵇ and <: om. IV<sub>1</sub> <sup>16</sup>°ktiḥ P<sub>1</sub> <sup>17</sup>eva  
R <sup>18</sup>grahamandabhuktais (°ktai V<sub>1</sub>) IV<sub>1</sub>; °kte P<sub>2</sub>; °ktaiḥ P<sub>1</sub>; °ktau S <sup>19</sup>°occam bhū° RP<sub>2</sub>; °kti  
P<sub>1</sub> <sup>20</sup>sārdhā for s̄a ca RP<sub>2</sub>; om., va is inserted by DY P<sub>1</sub> <sup>21</sup>°taram guṇi° RP<sub>2</sub> <sup>22</sup>atra śeṣa° R;  
avaśeṣa° P<sub>2</sub>S <sup>23</sup>kriyā° P<sub>1</sub> <sup>24</sup>yat IV<sub>1</sub>; ya P<sub>2</sub> <sup>25</sup>abhavaṃty IV<sub>1</sub>; bhavet S <sup>26</sup>ena IV<sub>1</sub>; te P<sub>1</sub>; tad  
S <sup>27</sup>guṇanoyety IV<sub>1</sub> <sup>28</sup>bhuktā R <sup>29</sup>°yāḥ P<sub>1</sub> <sup>30</sup>°jīvayā IV<sub>1</sub>; ādyā jīvayā P<sub>1</sub>; om. S <sup>31</sup>°thama I  
<sup>32</sup>om. IV<sub>1</sub> <sup>33</sup>guṇām P<sub>2</sub>

**bhagaṇāṃśahr̥taṃ**<sup>1</sup> ca kṛtvā yat<sup>2</sup> phalaṃ tāḥ kalāḥ<sup>3</sup> | tābhiḥ **phalakalā-**  
**bhiḥ**<sup>4</sup> | **mṛgakarkyādau**<sup>5</sup> sthite svamandakendre yathāsaṃkhyam **ūnādhikā**<sup>6</sup> S p. 211  
sati<sup>7</sup> **svamadhya**(ma)**gatir**<sup>8</sup> mandasphuṭā bhavati | bhaumādīnām sā manda- P1 p. 182  
sphuṭaivocyate<sup>9</sup> | ravicandrayos tu saiva paramārthasphuṭā<sup>10</sup> yatas tau mandaprati- R 34v  
maṇḍale bhramata<sup>11</sup> iti ||

atreyaṃ vāsanā | kakṣāmaṇḍale<sup>12</sup> yatra pradeśe ravir<sup>13</sup> vartate<sup>14</sup> candro<sup>15</sup> vā  
bhaumādīnām svaśighranīcoccavṛttamadhyaṃ<sup>16</sup> vā tatra<sup>17</sup> yaj<sup>18</sup> jyāntaraṃ tena  
saha trairāśikam | ▷yadi tat(t)vayamasamkhyābhir<sup>19</sup> liptābhir jyāntaraṃ<sup>20</sup> labh-  
yate tan<sup>21</sup> mandakendrabhuktiliptābhiḥ<sup>22</sup> kim iti | dvitīyaṃ trairāśikam | yadi  
ṣaṣṭīśatatravṛtte<sup>23</sup> phalaṃ<sup>24</sup> jyārūpam etāvāt svamandoccanīcavṛtte<sup>25</sup> kiyad iti P2 p. 60  
| tatas<sup>26</sup> tr̥tīyaṃ trairāśikam<sup>27</sup> | yadi manuyamalatulyasya<sup>28</sup> jyārūpasya<sup>29</sup> tattva-  
yamasamkhyā<sup>30</sup> cāpaliptā bhavanti<sup>31</sup> tad asya<sup>32</sup> kiyatya iti<sup>33</sup> |

evaṃ prathamatrairāśīke tattvayamasamkhyo<sup>34</sup> ▷bhāgahāras tr̥tīye guṇakārah |  
atas<sup>35</sup> tayor nāśe<sup>36</sup> kṛte mandakendrabhukter<sup>37</sup> jyāntaraṃ guṇakāra<sup>38</sup> ādyā<sup>39</sup>  
jīvā bhāgahārah<sup>40</sup> | tato yad āptaṃ tasya svamandaparidhir<sup>41</sup> guṇakārah ṣaṣṭī-  
śatatravṛtā<sup>42</sup> bhāgahārah<sup>43</sup> | phala(sya)<sup>44</sup> svabhuktāv<sup>45</sup> apacaya upacayo<sup>46</sup> vā |  
kakṣāmaṇḍalāt<sup>47</sup> pratimaṇḍalam<sup>48</sup> upari yatra tatra bhukter apacayo yatrādhā IV1 66v  
tatropacayah<sup>49</sup> | ata<sup>50</sup> eva<sup>51</sup> coktaṃ<sup>52</sup> **mṛgakarkyādāv**<sup>53</sup> **ūnādhikā svamadhya-**  
**magatir**<sup>54</sup> iti | etat sarvaṃ<sup>55</sup> yathānyasteṣu<sup>56</sup> kakṣāmaṇḍalādiṣu<sup>57</sup> pradarśayed  
upapannaṃ ca |

<sup>1</sup>between ▷ and ◁: sphuṭamaṇḍaparidhiguṇitaṃ bhagaṇāṃśahr̥taṃ IV1; sphuṭasvamaṇḍaparidhi-  
nā guṇāṇāṃśahr̥taṃ R; sphuṭasvamaṇḍaparidhinā guṇāṃ bhāṃśahataṃ P2; sphuṭamaṇḍaparidhi-  
guṇaṃ bhagaṇāṃśahataṃ P1; sphuṭamaṇḍaparidhiguṇabhagaṇāṃśahr̥taṃ S <sup>2</sup>yatat P1; yat tat S  
<sup>3</sup>kalās R; kalās P2 <sup>4</sup>phalā° P1 <sup>5</sup>°karkyadau I; °karkādaḥ P2; ṣṭagavākyādaḥ P1 <sup>6</sup>°dhiko P2; ūnāḥ  
[p. 182] dhikā P1 <sup>7</sup>sati, ti is underlined and commented by the scribe: tī P2 <sup>8</sup>°madhyagatir IV1;  
svayamadhyagatir P2; °madhyagati P1; °madhyagatiḥ S <sup>9</sup>°sphuṭair vaivocyate P2; °sphuṭe taitya  
ucyate P1; °sphuṭaivetya ucyate S <sup>10</sup>°ārtheyo sphuṭā IV1; °ārthyasphuṭā S <sup>11</sup>°mataḥ <sup>12</sup>kakṣyā°  
V1RP2 <sup>13</sup>ravi P2 <sup>14</sup>varttate IV1RP2; vatate S <sup>15</sup>candrau P1 <sup>16</sup>svamaṇḍanīcoccamadhyakṛtaṃ  
P1, kṛtaṃ corrected to vṛttaṃ by DY; S=DY <sup>17</sup>yatra RP2 <sup>18</sup>om. IV1; ya P2P1 <sup>19</sup>tatva° RP2P1  
<sup>20</sup>jyāntaraṃ P1 <sup>21</sup>tadā S <sup>22</sup>°liptābhi P2; °bhuktiḥ liptābhiḥ P1 <sup>23</sup>°kṛte P1 <sup>24</sup>yat + phalaṃ  
IV1P1S <sup>25</sup>°nīce vṛtte RP2; °kṛte P1 <sup>26</sup>tataḥ P1S <sup>27</sup>between ▷ and ◁: om. IV1 <sup>28</sup>°yamalātulya-  
RP2 <sup>29</sup>yāphalasya RP2P1; jyāphalasya S <sup>30</sup>tatva° IV1RP2 <sup>31</sup>bhavati S <sup>32</sup>tadāsyā for tad asya  
P1 <sup>33</sup>for kiyatya iti: kiyatyadraty P1; kiyat prabhavaty S <sup>34</sup>tatva° IV1RP2; °yamaṃ samstho P1  
<sup>35</sup>S P2 <sup>36</sup>nnāśe R; nnāśa- P2 <sup>37</sup>°kte R <sup>38</sup>°kārah IV1; °kāra R; °kārar P2 <sup>39</sup>yā R <sup>40</sup>bhāgā° RP2  
<sup>41</sup>°dhi RP2 <sup>42</sup>between ▷ and ◁: om. P1S <sup>43</sup>bhāgā° P2 <sup>44</sup>phalaṃ IV1RS; ra(?) phalaṃ, '(?)' is  
given by the scribe P2; phala P1 <sup>45</sup>°bhaktāv P1 <sup>46</sup>for apacaya upacayo: upacayo pacayayo IV1;  
upacayāpacayo corrected to upacayo pacayo by DY P1; upacayāpacayo S <sup>47</sup>kakṣyā° IV1; kakṣyān  
ma° R; kakṣān ma° P2 <sup>48</sup>°ḍalas P1 <sup>49</sup>tatrāpa° P1 <sup>50</sup>te P1 <sup>51</sup>evaṃ P1 <sup>52</sup>evoktaṃ (ca om.)  
RP2 <sup>53</sup>°ādau IV1; mṛgakakṣyār̥kādv (°kākṣā° P2) RP2 <sup>54</sup>°madhyagatir IV1P1S <sup>55</sup>sarva P2  
<sup>56</sup>°nyesteṣu IV1; yathātatteṣu P1S <sup>57</sup>mkakṣyā° IV1R

yadi nāma candramandakendrabhuktir<sup>1</sup> bahuḥjāntaravyāpini<sup>2</sup> tatra kecic<sup>3</sup>  
candrākrāntajyāntarād<sup>4</sup> ārabhyātītajyāntarair<sup>5</sup> bhukteh<sup>6</sup> sphuṭikaraṇam icchanti<sup>7</sup>  
| apare tata evāgāmiḥjyāntarair<sup>8</sup> ▷\*anye<sup>9</sup> 'tītaiṣyadjyāntaraiḥ<sup>10</sup> sphuṭayoś<sup>11</sup> ca<sup>12</sup>  
saṃyogārdhena\*<sup>13</sup> karma<sup>14</sup> kurvate | evam<sup>15</sup> āgāmiḥjyāntarair api sphuṭayā<sup>16</sup>  
saha yogārdhena | apare<sup>17</sup> tu punar<sup>18</sup> gatāt kālānāyane<sup>20</sup> 'tītai<sup>21</sup> jyāntaraiḥ P<sub>1</sub> p. 183  
▷sphuṭayāgamyāc<sup>22</sup> ca kālānāyane<sup>23</sup> nāgatajyāntarasphuṭayā<sup>25</sup> candrabhuktyā<sup>26</sup>  
karma kurvate<sup>27</sup> |

na<sup>28</sup> ca<sup>29</sup> sphuṭabhuktiḥ<sup>30</sup> kṣaṇam apy<sup>31</sup> ekā<sup>32</sup> vaktuṃ śakyate<sup>33</sup> kakṣāmaṇḍala-  
pratimaṇḍalayor<sup>34</sup> anyathāsamsthānāt<sup>35</sup> | tasmād anavasthāprasaṅgaḥ<sup>36</sup> syād ity  
▷ācāryeṇa candrākrāntajyāntareṇaiva<sup>37</sup> bhuktijyānītā<sup>38</sup> svalpāntaratvāt<sup>39</sup> | evam  
ravyādīnām api vikalp<sup>40</sup> sambhavanti yadi nāmātyalpam antaram<sup>42</sup> teṣāṃ  
bhukter alpatvād iti | yac cāpakaraṇam<sup>43</sup> asyām<sup>44</sup> āryāyām<sup>45</sup> ādyajīvyā sthirayopa-  
nibaddham tad anyeṣāṃ<sup>46</sup> jyāntarānām<sup>47</sup> asambhavād yato<sup>48</sup> bhuktijyāphalam<sup>49</sup> su-  
bahv api<sup>50</sup> manuyamalānām<sup>51</sup> liptānām tulyam<sup>52</sup> na bhavati<sup>53</sup> | tasmāt<sup>54</sup> sarvam<sup>55</sup>  
upapannam iti<sup>56</sup> ||

## II.2 Translation

Now he tells one and half āryās for the correction of the daily motion of all the planets by the manda equation.

**The daily motion of the manda anomaly of a planet is multiplied by the difference of the sines and divided by the first sine.**

<sup>1</sup>°kti P<sub>1</sub>; manda om. S <sup>2</sup>°taram vyā° IV<sub>1</sub>; °pinā P<sub>2</sub> <sup>3</sup>kendravac S <sup>4</sup>°krānti° RP<sub>2</sub> <sup>5</sup>ābhyā°  
corrected to ārabhyā° by DY P<sub>1</sub> <sup>6</sup>°ktaih IV<sub>1</sub>; °ktiḥ RP<sub>2</sub> <sup>7</sup>idaṃty IV<sub>1</sub>; ichaṃty RP<sub>1</sub> <sup>8</sup>evāgami°  
RP<sub>2</sub> <sup>9</sup>abhye P<sub>2</sub> <sup>10</sup>°ṣyatjyā° R; °ṣyatjyāntarai P<sub>2</sub> <sup>11</sup>sphuṭā yāḥ R <sup>12</sup>sva- R <sup>13</sup>between \*s:  
om. P<sub>1</sub>S <sup>14</sup>karmā P<sub>1</sub> <sup>15</sup>after this is inserted: atītaiḥ sphuṭayā (°ṭayā S) P<sub>1</sub>S <sup>16</sup>°ṭayāḥ P<sub>1</sub>  
<sup>17</sup>aparai P<sub>2</sub> <sup>18</sup>manur P<sub>1</sub> <sup>19</sup>between ▷ and ◁: om. IV<sub>1</sub> <sup>20</sup>kālana° P<sub>1</sub>; kalāna°S <sup>21</sup>tītai P<sub>1</sub>  
<sup>22</sup>°gamyāś IV<sub>1</sub>; °gamyā P<sub>1</sub> <sup>23</sup>°nayanai IV<sub>1</sub> <sup>24</sup>between ▷ and ◁: sphuṭayā gamyāvakālānāyane  
S <sup>25</sup>nāgate jyāntaragatayā sphuṭayā P<sub>1</sub>S <sup>26</sup>°bhuktā P<sub>1</sub>; °bhuktau S <sup>27</sup>kurute RP<sub>2</sub>S <sup>28</sup>ta  
P<sub>1</sub> <sup>29</sup>va P<sub>2</sub>; for na ca: tatra S <sup>30</sup>sphuṭā bhukti RP<sub>2</sub>; sphuṭā bhuktiḥ P<sub>1</sub>S <sup>31</sup>ath P<sub>1</sub>; madhye S  
<sup>32</sup>ekam RP<sub>2</sub> <sup>33</sup>na is inserted before this RP<sub>2</sub> <sup>34</sup>kakṣyā° V<sub>1</sub>RP<sub>2</sub>; °maṇḍalam prati° corrected  
to °maṇḍalaprati° by DY P<sub>1</sub> <sup>35</sup>for anyathā: anyathā' nyathā RP<sub>2</sub>; iti yathā P<sub>1</sub> <sup>36</sup>°saṅga IV<sub>1</sub>;  
ṛnavasthāpasamga P<sub>2</sub> <sup>37</sup>candrā om. S <sup>38</sup>°nītās RP<sub>2</sub> <sup>39</sup>tulyāntaram tvād RP<sub>2</sub> <sup>40</sup>... ās I; ... ā  
V<sub>1</sub>; kalpāḥ P<sub>1</sub>S <sup>41</sup>between ▷ and ◁: om. IV<sub>1</sub> <sup>42</sup>amtare P<sub>1</sub>S <sup>43</sup>°kāraṇam S <sup>44</sup>om. P<sub>2</sub> <sup>45</sup>°yāyam  
RP<sub>2</sub> <sup>46</sup>tvadanye° RP<sub>2</sub> <sup>47</sup>°taṇām P<sub>2</sub> <sup>48</sup>°yātā R; yate P<sub>1</sub> <sup>49</sup>°phalām P<sub>1</sub>S <sup>50</sup>for subahv api:  
tuvadkāpi P<sub>1</sub>; śuvadvāpi S <sup>51</sup>manuyamalā- RP<sub>2</sub> <sup>52</sup>tulyo corrected to tulyām by DY P<sub>1</sub>; tulyā S  
<sup>53</sup>bhavanti S <sup>54</sup>tasmāgat P<sub>1</sub>; tasmād uktaṃ S <sup>55</sup>svarvas P<sub>1</sub> <sup>56</sup>iti (i P<sub>2</sub>) 4;11,2 RP<sub>2</sub>

**The result is multiplied by the corrected circumference (of its manda epicycle) and divided by the degrees of a rotation. The mean daily motion of the sun or the moon becomes true when it is decreased or increased by the minutes of the result (as it is in the anomalistic semicircles) beginning with Capricorn (i.e., the fourth and first quadrants) or Cancer (i.e., the second and third quadrants) (respectively).**

Whatever is the anomaly of the planet in the manda calculation, that is **the manda anomaly of the planet**; the **daily motion** of that (is discussed). As an anomaly is produced when one subtracts (the longitude of) its manda apogee from (the longitude of) the mean planet, in the same manner the daily motion of (manda) anomaly is produced when one subtracts the daily motion of its manda apogee from the mean daily motion of the planet. It is multiplied by **the difference of the sines**. The meaning is: whatever was the difference of the sines when the sine of the bhuja was being computed in the manda computation without a remainder (i.e., by iteration), it is to be multiplied by that. Then it is **divided by the first sine**. **The first sine** means the first sine, 214. Whatever is **the result** from that, that is **multiplied by the corrected circumference** of its manda (epicycle) and **divided by the degrees of a rotation**. Whatever is the result is (expressed in) minutes. **By those minutes of the result**, when its manda anomaly stands (**in the anomalistic semicircles**) beginning with **Capricorn (i.e., the fourth and first quadrants) or Cancer (i.e., the second and third quadrants)**, its **mean daily motion decreased or increased** respectively is manda-corrected. In the case of (the planets) beginning with Mars the (result) is called only 'manda-corrected.' But that of the sun or the moon is completely corrected because these two rotate on only (their) manda eccentric circle(s).

Here is this explanation: At whatever place on (its) orbit is the sun, the moon, or the center of the śīghra epicycle of Mars etc., there there is the rule of three with the difference of the sines. If the difference of the sines is obtained by 225 minutes, then what is (obtained) by the minutes of the daily motion of the manda anomaly? The second rule of three: if a result in the form of a sine pertaining to a circle (whose circumference is) 360 (degrees) is this much, how much is it pertaining to its manda epicycle? Then the third rule of three: if 225 minutes of arc pertaining to (the result) having the form of a sine is equal to 214, then how much pertain to this (result)?

In this way, 225 is the divisor in the first rule of three and the multiplier in the third. Therefore, when these two are removed, the difference of the sines is the multiplier of the daily motion of the manda anomaly and the first sine is its divisor. Then whatever is obtained, the circumference of the manda (epicycle) is its multiplier and 360 is its divisor. The subtraction or addition of the result (is

made) to or from its own (mean) daily motion: wherever the eccentric circle is above the orbit, subtraction from the daily motion (is made, and) wherever (it is) below addition (is made). Therefore it is said: **“its mean daily motion is decreased or increased (as it is in the anomalistic semicircles) beginning with Capricorn (i.e., the fourth and first quadrants) or Cancer (i.e., the second and third quadrants) (respectively).”** One should illustrate all of this in the orbits and so on as they were set down (in a diagram); and it is demonstrated.

In the case that the daily motion of the manda anomaly of the moon entails many differences of sines, some (astronomers) want to make the correction of the daily motion by means of the differences of the past sines beginning with the difference of the sines occupied by the moon. Others (wish to make the correction) by means of the future differences of the sines, (and) others make the calculation by means of half of the sum (of the daily motions) corrected by means of the past and future differences of the sines; in this way, it is by means of half the sum together with (the lunar daily motion) corrected by the future differences of the sines. Others however make the calculation by means of (the lunar daily motion) corrected by the past differences of the sines when the calculation of the time is from a past (time) and by means of the lunar daily motion corrected by the future differences of the sines when the calculation of the time is from a future (time).

The true daily motion cannot be said to be the same even for a moment because the orbit and the eccentric circle are standing in the different relationship. Therefore, (thinking) ‘there might be a suspicion of instability,’ the sine of the daily motion is computed by the teacher with only the difference of the sines occupied by the moon because the difference is very small.

In like manner there occur also in the cases of the sun and so on doubts such as: ‘if the difference is very small, it is because their daily motion is small.’

Whatever computation of the arc is mentioned in this *āryā* by means of a fixed first sine, that is because the other differences of the sines are impossible since the result of the sine of the daily motion when it is very large is not equal to the 214 minutes (of the first sine). Therefore, everything is demonstrated.

### II.3 Mathematical Commentary

The rule described in these verses is sometimes called *jīvabhukti*, ‘daily motion calculated by means of Rsins’<sup>1)</sup>. In BSS this rule is used for correcting mean motion into ‘manda-corrected’ motion by the manda equation.

Figure 1 shows mean positions ( $\bar{p}_1$  and  $\bar{p}_2$ ) and manda-corrected positions ( $p_1$  and  $p_2$ ) of the planet in successive two days. The manda apogee (A) is fixed in this figure, so that the vernal equinox ( $\gamma 0_1$  and  $\gamma 0_2$ ) apparently changes its position by the daily motion of the manda apogee ( $v_A$ ).

We can compute the mean and manda-corrected daily motions of the planet ( $\bar{v}$  and  $v$  respectively) from  $v_A$  and mean and manda-corrected daily motions of



anomaly (the angular distance of the planet from  $A$ ), ( $\bar{v}_\alpha$  and  $v_\alpha$  respectively):

$$\bar{v} = \bar{v}_\alpha + v_A,$$

$$v = v_\alpha + v_A.$$

Therefore, the difference between the mean daily motion and the manda-corrected daily motion is:

$$|\bar{v} - v| = |\bar{v}_\alpha - v_\alpha| = \varepsilon.$$

The main purpose of the *jvabhukti* rule is to calculate this  $\varepsilon$ .

According to Pr̥thūdakasvāmin, three ‘rules of three’ or proportions are used to compute  $\varepsilon$  (figure 2). First,  $D$  is calculated by means of a proportion which is called the ‘first rule of three’ in Pr̥thūdaka’s commentary:

$$I : \Delta J_\alpha = \bar{v}_\alpha : D,$$

where  $I$  is the interval of the Rsine table (225' in BSS) and  $\Delta J_\alpha$  is the difference of the two successive tabulated Rsines containing the angle  $\alpha$ .

Then  $D$  is reduced to  $d$  in the manda epicycle by means of the ‘second rule of three’. Let  $c$  be the circumference of the manda epicycle expressed in degrees when the circumference of the standard circle is 360:

$$360 : D = c : d.$$

And finally, assuming  $d$  to be  $\text{Sin } \varepsilon$  ( $R \sin \varepsilon$ ), he convert it into an arc by means of the ‘third rule of three’:

$$J[1] : I = d(\approx \text{Sin } \varepsilon) : \varepsilon,$$

where  $J[1]$  is the first tabulated Rsine (214 in BSS).

When these three proportions are combined, we get the formula Brahmagupta gives:

$$\varepsilon = \bar{v}_\alpha \cdot \frac{\Delta J_\alpha}{J[1]} \cdot \frac{c}{360}.$$

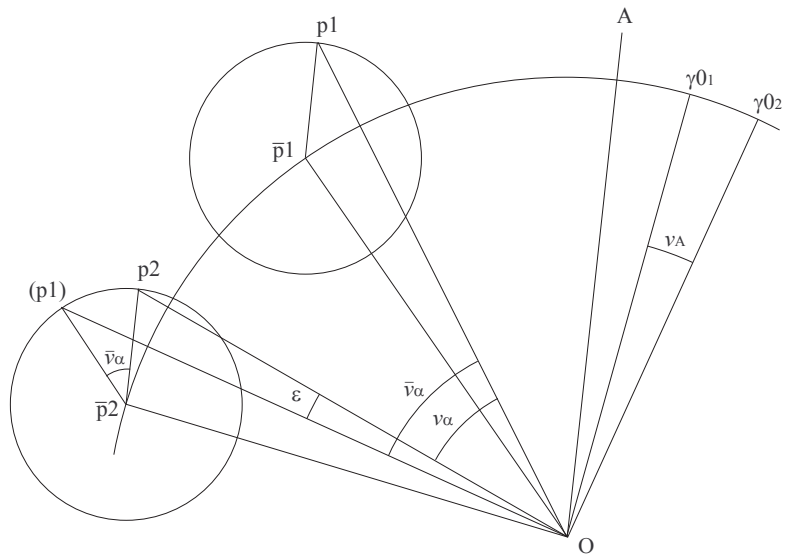


Figure 1:

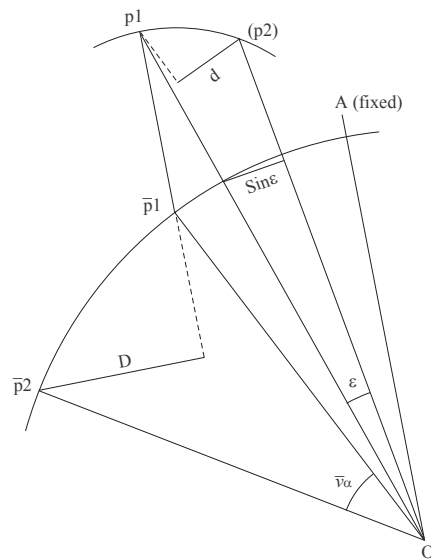


Figure 2:

### III BSS II, 42cd–44

#### III.1 Text

(IV<sub>1</sub> 66v l. -2; R 34v l. -1; P<sub>2</sub> p. 60 l. -9; P<sub>1</sub> p. 183 l. 12; S p. 211 l. -11)

idānīm bhaumādīnām <sup>▷</sup>bhukteḥ<sup>1</sup> sphuṭikaraṇārtham<sup>◁2</sup> āryādvayaṃ<sup>3</sup> sārddham R 35r  
āha ||

śīghragatiṃ<sup>4</sup> mandaphala-  
sphuṭabhuktyūnām<sup>5</sup> kujādīnām<sup>6</sup> || 42cd

śīghraphalabhogyajīvā-  
saṃguṇitām<sup>7</sup> ādyajīvayā<sup>8</sup> vibhajet |

IV<sub>1</sub> 67r

phalaguṇitaṃ vyāsārdham<sup>9</sup>  
vibhājayec<sup>10</sup> chīghrakarṇena<sup>11</sup> || 43

labdhonā śīghragatiḥ<sup>12</sup>  
sphuṭabhuktir<sup>13</sup> bhavati<sup>14</sup> labdham adhikaṃ cet |

śīghragateḥ<sup>15</sup> śīghragatiṃ  
labdhāt<sup>16</sup> saṃśodhya vakragatiḥ<sup>17</sup> || 44

kujādīnām tārāgrahānām<sup>18</sup> śīghragatiṃ<sup>19</sup> kimbhūtām<sup>20</sup> | mandaphala-  
sphuṭabhuktyūnām<sup>21</sup> śīghraphalabhogyajīvāsamguṇitām<sup>22</sup> ca | satīm<sup>23</sup> vi-  
bhajet | kayā<sup>24</sup> | ādyajīvayā |

etad uktaṃ bhavati | bhaumāder<sup>25</sup> grahasya pūrvapradarśitena<sup>26</sup> karmaṇā yā<sup>27</sup> P<sub>2</sub> p. 61  
mandaphalasphuṭabhuktis<sup>28</sup> tāṃ svaśīghrabhukteḥ<sup>29</sup> saṃśodhya<sup>30</sup> mandaphala- P<sub>1</sub> p. 184  
sphuṭabhuktyūnā<sup>31</sup> śīghragatir<sup>32</sup> bhavati | tatas tāṃ guṇayec<sup>33</sup> chīghraphala-  
bhogyajīvayā<sup>34</sup> | grahasya sphuṭikriyamānasya<sup>35</sup> yac<sup>36</sup> chīghraphalaṃ bhavati

<sup>1</sup>°te P<sub>2</sub> <sup>2</sup>between ▷ and ◁: bhuktikaraṇārtham S <sup>3</sup>°yam P<sub>1</sub> <sup>4</sup>°gatir IV<sub>1</sub>; °gati RP<sub>2</sub>; °gatiṃ corrected to gati by DY P<sub>1</sub> <sup>5</sup>°phalaṃ sphuṭabhuktyūnā IV<sub>1</sub>; °bhuktānām RP<sub>2</sub> <sup>6</sup>after this is inserted: ca R <sup>7</sup>in P<sub>1</sub> KN gives the same text as D but DY corrects it to the form seen in IV<sub>1</sub>RP<sub>2</sub> which I employed here. <sup>8</sup>°vayāsyā R; °vayāyā P<sub>2</sub> <sup>9</sup>°rdham corrected to °rdhyaṃ by DY P<sub>1</sub> <sup>10</sup>°yet RP<sub>2</sub>; vibhājayet corrected to vibhājyaye by DY P<sub>1</sub> <sup>11</sup>śīghra° RP<sub>2</sub>; °karṇena P<sub>1</sub> corrected to °karaṇena by DY <sup>12</sup>°gati IV<sub>1</sub>R; °(ga)ti, (ga) is underlined and commented by the scribe: not in ms. P<sub>2</sub> <sup>13</sup>°ktir P<sub>1</sub> corrected to °kti by DY <sup>14</sup>om. RP<sub>2</sub> <sup>15</sup>°gatera I; °gate V<sub>1</sub>; °gāvaḥ R <sup>16</sup>°dhān I; °dhā RP<sub>2</sub>; °dhāt corrected to dhā by DY P<sub>1</sub> <sup>17</sup>cakra° R <sup>18</sup>tāra° P<sub>1</sub> <sup>19</sup>°gati P<sub>1</sub>; °gatiḥ S <sup>20</sup>°bhūto P<sub>1</sub>; °bhūtānām S <sup>21</sup>mandaphalaḥ sphuṭabhaktīnām P<sub>1</sub>; °bhuktīnām S <sup>22</sup>°bhojya° IV<sub>1</sub>P<sub>1</sub>; °guṇitā S <sup>23</sup>satī P<sub>1</sub>S <sup>24</sup>kṣaya R; kṣayaḥ P<sub>2</sub> <sup>25</sup>°mādre P<sub>1</sub> <sup>26</sup>°darśanena R; °darśya tena P<sub>2</sub>; °darśitane P<sub>1</sub> <sup>27</sup>om. S <sup>28</sup>°sphuṭā bhuktis IV<sub>1</sub>; me[p. 184]daphala°bhuktiḥ P<sub>1</sub> <sup>29</sup>°ktes I; °kte V<sub>1</sub>R; svām śīghrabhukte P<sub>2</sub>; °bhukte P<sub>1</sub> <sup>30</sup>°śīśodhya P<sub>1</sub>S <sup>31</sup>°bhuktīnām corrected to °bhuktyānām by DY P<sub>1</sub>; °bhuktīnām S <sup>32</sup>śī(ghra)°, (ghra) is underlined and commented by the scribe, “not in ms.” P<sub>2</sub> <sup>33</sup>°ye IV<sub>1</sub>R; °yet P<sub>1</sub> <sup>34</sup>°bhojya° IV<sub>1</sub>; °bhojayā P<sub>1</sub>; °bhogyayā S <sup>35</sup>°māṇasya P<sub>1</sub> <sup>36</sup>ya P<sub>1</sub>

tasya phalasya<sup>1</sup> jyāyām<sup>2</sup> kriyamānāyām<sup>3</sup> yaj<sup>4</sup> jyāntaram<sup>5</sup> guṇakāraḥ<sup>6</sup> sambhavati<sup>7</sup>  
 | sā śīghraphalabhogyajīvety ucyate<sup>8</sup> | tayā mandaphalasphuṭabhuktyūnām<sup>9</sup>  
 śīghragatiṃ<sup>10</sup> saṃguṇayyādyajīvayā<sup>11</sup> vibhajet<sup>12</sup> | manuyamalair ity arthaḥ |  
 tato yat phalaṃ tena phalena guṇitaṃ vyāsārdham<sup>13</sup> vibhājayec chīghra-  
 karṇena<sup>14</sup> | tato 'pi yal labdham<sup>15</sup> tena sarvadā śīghragatir<sup>16</sup> ūnā kartavyā<sup>17</sup> |  
 sā conākṛtā<sup>18</sup> grahasya sphuṭabhuktis tatra<sup>19</sup> pradeśe<sup>20</sup> sthitasya bhavati |

labdham adhikaṃ cec chīghragateḥ<sup>21</sup> | phalaguṇitād<sup>22</sup> vyāsārdhāc<sup>23</sup>  
 chīghrakarṇahr̥tād<sup>24</sup> yal labdham<sup>25</sup> tad<sup>26</sup> yadi<sup>27</sup> śīghragater atyadhikaṃ<sup>28</sup> bhavati  
 tadā śīghragatiṃ<sup>29</sup> labdhāt<sup>30</sup> saṃśodhya vakragatir<sup>31</sup> bhavati | viparītaśodhane<sup>32</sup>  
 kṛte 'vaśeṣā<sup>33</sup> vakrabhuktir<sup>34</sup> bhavati<sup>35</sup> | tadaivaitat<sup>36</sup> sambhavatīty arthaḥ<sup>37</sup> |  
 yadi nāmāsyā<sup>38</sup> bhaumasyaāyāṃ viśeṣaḥ | prathamam<sup>39</sup> mandaphalam uktavad<sup>40</sup>  
 ānīyā<sup>41</sup> tadardham<sup>42</sup> madhyabhuktāv<sup>43</sup> ṛṇam dhanam vā<sup>44</sup> kāryam | tatas tad-  
 ūnaśīghrabhuktiṃ<sup>45</sup> ḍśīghraphalārdhahajabhogyajīvāsāṃguṇitām<sup>46</sup> ādyajīvayā<sup>47</sup> vi-  
 bhajet | labdhenoktavat sphuṭabhuktiṃ<sup>48</sup> samānīyā<sup>49</sup> tayā saha mandaphalārdha-  
 sphuṭabhukter yad antarārdham<sup>50</sup> tat<sup>51</sup> tatraivaikakarmakṛtabhuktau<sup>52</sup> dhanam  
 ṛṇam vā<sup>53</sup> kāryam | yadi mandasphuṭabhukter adhikā sphuṭabhuktis<sup>54</sup> tad dhanam  
 anyatharṇam<sup>55</sup> iti<sup>56</sup> | evaṃ kṛte dvikarmasphuṭā<sup>57</sup> bhaumabhuktir bhavati | tām  
 madhyām parikalpyā<sup>58</sup> śeṣagrahavat<sup>59</sup> bhukter<sup>60</sup> api<sup>61</sup> sphuṭikaraṇam<sup>62</sup> iti | kakṣā-  
 maṇḍalādīni<sup>63</sup> yathāvinasya<sup>64</sup> sarvam<sup>65</sup> darśayet<sup>66</sup> |

S p. 212

IV<sub>1</sub> 67vP<sub>1</sub> p. 185

R 35v

<sup>1</sup>phalaṃ P<sub>1</sub> <sup>2</sup>for phalasya jyāyām: phalajyāyām S <sup>3</sup>kṛyamānāyām corrected to kriyamānāyām  
 by DY P<sub>1</sub> <sup>4</sup>yat R; ya P<sub>1</sub> <sup>5</sup>ntāram IV<sub>1</sub> <sup>6</sup>°kāras I; °kāra V<sub>1</sub>P<sub>2</sub>; °karaḥ P<sub>1</sub> <sup>7</sup>sa bhavati IV<sub>1</sub>P<sub>1</sub>  
<sup>8</sup>uccyate I; for °jīvety ucyate: °jīvayocyate P<sub>2</sub> <sup>9</sup>°bhuktīnām P<sub>1</sub>; sphuṭa om. S <sup>10</sup>°gati P<sub>1</sub> <sup>11</sup>  
 °yyājīvayā IV<sub>1</sub>; °guṇajyādyā° RP<sub>2</sub> <sup>12</sup>°jeran I; °jeranū V<sub>1</sub>; vibhajyajet P<sub>1</sub> <sup>13</sup>after this is inserted:  
 sad IV<sub>1</sub>P<sub>1</sub>, tad S; °rddha RP<sub>2</sub> <sup>14</sup>chīghram karṇena RP<sub>2</sub> <sup>15</sup>°dhām P<sub>1</sub> <sup>16</sup>°gatiḥ IV<sub>1</sub>; °gatin P<sub>1</sub>  
<sup>17</sup>kartavyā IV<sub>1</sub>RP<sub>2</sub>S <sup>18</sup>conā ṛṇa satī RP<sub>2</sub> <sup>19</sup>tata P<sub>1</sub>; tataḥ S <sup>20</sup>°deśo P<sub>1</sub> <sup>21</sup>cet śīghragateḥ  
 (P<sub>1</sub> °gate) P<sub>2</sub>P<sub>1</sub> <sup>22</sup>°tāt R; phalaṃ guṇitāt P<sub>2</sub>; °tāda P<sub>1</sub> <sup>23</sup>°dhā IV<sub>1</sub>R; °rdha- P<sub>1</sub> <sup>24</sup>°hatād  
 P<sub>2</sub>; °karṇād gatād P<sub>1</sub> <sup>25</sup>for yal labdham: ālabdhe R; yalabdhe P<sub>2</sub>; yac ca labdham P<sub>1</sub> <sup>26</sup>tat P<sub>1</sub>  
<sup>27</sup>yati IV<sub>1</sub>; om. P<sub>1</sub>S <sup>28</sup>apy adhi° IV<sub>1</sub>P<sub>2</sub>; athādhi° P<sub>1</sub>S <sup>29</sup>°gati P<sub>2</sub>P<sub>1</sub>S <sup>30</sup>labdhā R; labdhām P<sub>1</sub>S  
<sup>31</sup>°gati P<sub>1</sub> <sup>32</sup>°sodhane P<sub>1</sub> <sup>33</sup>ca śeṣā R; 'thā P<sub>1</sub>; 'py S <sup>34</sup>°kti P<sub>1</sub>; avakra° S <sup>35</sup>bhavati corrected  
 to bhavanti by DY P<sub>1</sub> <sup>36</sup>tad evaitat P<sub>2</sub> <sup>37</sup>a P<sub>2</sub> <sup>38</sup>nāma (asya om.) RP<sub>2</sub>P<sub>1</sub>S <sup>39</sup>°thama IV<sub>1</sub>P<sub>1</sub>S;  
 pratha P<sub>2</sub> <sup>40</sup>for mandaphalam uktavad: °phalasuktatad corrected to °phalasukṛtad by DY P<sub>1</sub>;  
 mandaphalasaṃskṛtād S <sup>41</sup>°ānīyā P<sub>1</sub> <sup>42</sup>°ardha P<sub>1</sub> <sup>43</sup>°bhuktā P<sub>1</sub> <sup>44</sup>om. IV<sub>1</sub> <sup>45</sup>°ūnam śī°  
 RP<sub>2</sub>; °ūnām śī° P<sub>1</sub>S <sup>46</sup>°ārdhabhogyā° (ja om.) S <sup>47</sup>between ḍ and <: śīghraphalārdhabhogyajī-  
 vīvayā (°ārdham bhojya° P<sub>2</sub>) RP<sub>2</sub> <sup>48</sup>°kti P<sub>1</sub>; °ktiḥ S <sup>49</sup>°nīyam yadi P<sub>1</sub> <sup>50</sup>°ambharārdha P<sub>1</sub>  
<sup>51</sup>om. P<sub>2</sub>S <sup>52</sup>tatraikakarma° IV<sub>1</sub>; °kṛt bhuktau P<sub>2</sub>; tatraivaikakarmakṛta°, karma corrected to  
 karmma by DY P<sub>1</sub>; tatraivaikakarmakṛta° S <sup>53</sup>yā IV<sub>1</sub> <sup>54</sup>°ktiḥ P<sub>1</sub> <sup>55</sup>anyarṇam V<sub>1</sub>; °anyathārṇam  
 RP<sub>2</sub>P<sub>1</sub>S <sup>56</sup>ity artham, artham crossed out by DY P<sub>1</sub> <sup>57</sup>°karma° corrected to °karmma° by DY P<sub>1</sub>  
<sup>58</sup>°kalpyā R; °kalpā P<sub>2</sub>; pari (kalpya om.) P<sub>1</sub>S <sup>59</sup>°śeṣam graha° P<sub>2</sub>; °grahavat tad P<sub>1</sub>S <sup>60</sup>°kte P<sub>2</sub>  
<sup>61</sup>om. R <sup>62</sup>°karaṇam corrected to °karaṇām by DY P<sub>1</sub> <sup>63</sup>°kakṣyā° RP<sub>2</sub>; °ādīna P<sub>1</sub> <sup>64</sup>°vinasya  
 P<sub>1</sub> <sup>65</sup>sarva P<sub>2</sub>P<sub>1</sub> <sup>66</sup>°pradarśa° P<sub>1</sub>S

atreyaṃ<sup>1</sup> vāsanaḥ | mandaphalasphuṭo<sup>2</sup> graho yatra pradeśe kaksāmaṇḍale<sup>3</sup> var-  
tate<sup>4</sup> tatra śīghranīcoccaṃ<sup>5</sup> madhye<sup>5</sup> kṛte tatparidhīśīghrapratimaṇḍalaparidhyor<sup>6</sup>  
yatra sampātas<sup>7</sup> tatra sphuṭo grahaḥ | tasya svaśīghroccarekhayā<sup>8</sup> sahāntaraṃ  
yat<sup>9</sup> tat<sup>10</sup> pratidinam<sup>11</sup> upacīyate<sup>12</sup> svaśīghrabhuktimandaphalasphuṭabhuktyor<sup>13</sup> IV<sub>1</sub> 69r(!)  
antareṇa | yataḥ śīghraṃ<sup>14</sup> śīghrabhuktyā yāti<sup>15</sup> prāg mandasphuṭo mandasphuṭa-  
bhuktyā<sup>16</sup> cāto<sup>17</sup> mandasphuṭabhuktyūnā<sup>18</sup> śīghragatiḥ<sup>19</sup> kriyate | yac<sup>20</sup> ca<sup>21</sup> tayor  
antaraṃ śīghrakendrabhuktiḥ<sup>22</sup> bhavati | sā ca śīghrakendrabhuktiḥ<sup>23</sup> sphuṭīkriyate |  
tatra<sup>24</sup> yaiva<sup>25</sup> svaśīghranīcoccaṃ<sup>26</sup> madhyagā śalākā<sup>27</sup> saivāvadhitvena pari-  
kalpitā<sup>28</sup> ᵝphalacāpakaraṇe | yatas tata<sup>29</sup> eva yāvān<sup>30</sup> viprakarṣas tāvad<sup>31</sup> eva  
grahaphalam<sup>32</sup> atas<sup>33</sup> tata<sup>34</sup> evāvadheḥ<sup>35</sup> kramajyā pravartate<sup>36</sup> phalacāpakaraṇe  
| etac ca prāg evoktaṃ<sup>37</sup> śīghraphalānte ya<sup>38</sup> jyāntaraṃ<sup>39</sup> tena trairāśīkam<sup>40</sup> | yadi P<sub>2</sub> p. 62  
tattvayamais<sup>41</sup> tajjyāntaraṃ<sup>42</sup> labhyate tac<sup>43</sup> chīghrakendrabhuktiliptābhiḥ<sup>44</sup> kim<sup>45</sup>  
iti |

tato dvitīyaṃ trairāśīkam<sup>46</sup> | yadi<sup>47</sup> manuyamalais<sup>48</sup> tattvayamatulyāś<sup>49</sup> cāpa-  
liptā bhavanti<sup>50</sup> tal labdhajyākhaṇḍena<sup>51</sup> kim iti | atra<sup>52</sup> prathame<sup>53</sup> trairāśīke<sup>54</sup>  
tattvayamasamkhyo<sup>55</sup> bhāgahāro<sup>56</sup> dvitīye<sup>57</sup> guṇakārah | atas<sup>58</sup> tayor<sup>59</sup> naṣṭayoh<sup>60</sup>  
śīghrakendrabhukter<sup>61</sup> jyāntaraṃ guṇakāra<sup>62</sup> ādyajīva bhāgahārah | phalaṃ prati- P<sub>1</sub> p. 186  
maṇḍalasthagrahapradeśe<sup>63</sup> sphuṭā<sup>64</sup> śīghrakendrabhuktiḥ<sup>65</sup> |

<sup>1</sup>treyam IV<sub>1</sub>P<sub>1</sub>S    <sup>2</sup>phalaḥ sphuṭo P<sub>1</sub>    <sup>3</sup>kakṣyā° RP<sub>2</sub>    <sup>4</sup>pravarttate IV<sub>1</sub>; varttate RP<sub>2</sub>S  
<sup>5</sup> śīghroccanīcocca° IV<sub>1</sub>S    <sup>6</sup>śīghre prati° R; °śīghre pratimaṇḍalaparidhau P<sub>2</sub>    <sup>7</sup>taḥ P<sub>1</sub>  
<sup>8</sup>śīghrayoccarekhāyām IV<sub>1</sub>; °rokhayā P<sub>1</sub>; sva om. S    <sup>9</sup>yatas IV<sub>1</sub>    <sup>10</sup>om. RP<sub>2</sub>    <sup>11</sup>dinas P<sub>1</sub>  
<sup>12</sup>ūpa° corrected to upa° by DY P<sub>1</sub>    <sup>13</sup>svaśīghre bhukti° R; svaśīghre bhuktibhukti°bhuktyaur P<sub>2</sub>;  
°phalāsphuṭabhuktor P<sub>1</sub>    <sup>14</sup>om. IV<sub>1</sub>P<sub>1</sub>S    <sup>15</sup>di corrected to yadi by DY P<sub>1</sub>; S=DY    <sup>16</sup>manda om.  
P<sub>2</sub>    <sup>17</sup>vāto RP<sub>2</sub>P<sub>1</sub>; bhavati S    <sup>18</sup>maṇḍaphalasya sphuṭa° RP<sub>2</sub>; maṇḍaphalaṃ bhuktyūnā P<sub>1</sub>;  
mandaphalabhuktyūnā S    <sup>19</sup>gati IV<sub>1</sub>    <sup>20</sup>yena RP<sub>2</sub>; yac corrected to ya by DY P<sub>1</sub>    <sup>21</sup>for yac ca:  
tatra S    <sup>22</sup>kti P<sub>1</sub>    <sup>23</sup>kti R    <sup>24</sup>om. P<sub>1</sub>    <sup>25</sup>yeva P<sub>2</sub>; caiva S    <sup>26</sup>śīghroccanīcavṛtta° RP<sub>2</sub>; °kṛtasya  
corrected to vṛtasya by DY P<sub>1</sub>; sva om. S    <sup>27</sup>śālākā P<sub>1</sub>    <sup>28</sup>pari om. IV<sub>1</sub>; °pitāḥ P<sub>1</sub>    <sup>29</sup>between ᵝ  
and <: °karaṇe yatas tatas tata IV<sub>1</sub>; °karaṇāya taṃ atas tata R; °karaṇāya atas ta P<sub>2</sub>    <sup>30</sup>pādān RP<sub>2</sub>  
<sup>31</sup>tāvad corrected to tavad by DY P<sub>1</sub>    <sup>32</sup>phalas P<sub>2</sub>    <sup>33</sup>om. P<sub>2</sub>; ataḥ corrected to atas by DY P<sub>1</sub>  
<sup>34</sup>vata P<sub>1</sub>; tatra S    <sup>35</sup>dhe IV<sub>1</sub>; eva vedheḥ P<sub>2</sub>    <sup>36</sup>varttate IV<sub>1</sub>RP<sub>2</sub>S    <sup>37</sup>evokta IV<sub>1</sub>P<sub>1</sub>S    <sup>38</sup>ya P<sub>1</sub>  
<sup>39</sup>jyāphalāṃ P<sub>1</sub>; jyāphalaṃ S    <sup>40</sup>traī om. P<sub>1</sub>    <sup>41</sup>tattvayamalais IV<sub>1</sub>; tatva° RP<sub>2</sub>; tatrāyamalaiḥ P<sub>1</sub>;  
tattvayamalaiḥ S    <sup>42</sup>tatjyā° RP<sub>2</sub>; tajyā° P<sub>1</sub>    <sup>43</sup>ta IV<sub>1</sub>RP<sub>1</sub>    <sup>44</sup>bhi IV<sub>1</sub>P<sub>2</sub>    <sup>45</sup>kvim IV<sub>1</sub>    <sup>46</sup>om. P<sub>1</sub>S  
<sup>47</sup>om. P<sub>1</sub>S    <sup>48</sup>yamalaiḥ (manu om.) P<sub>1</sub>S    <sup>49</sup>tatva° IV<sub>1</sub>P<sub>1</sub>; tattvayamatulyāś R; tatrāyamatul-  
ulyāś P<sub>2</sub>    <sup>50</sup>bhavati IV<sub>1</sub>    <sup>51</sup>khaṇḍakena RP<sub>2</sub>; °jyām khaṇḍane P<sub>1</sub>; °khaṇḍane S    <sup>52</sup>atha RP<sub>2</sub>  
<sup>53</sup>thama RP<sub>2</sub>    <sup>54</sup>ko P<sub>1</sub>S    <sup>55</sup>tatva° IV<sub>1</sub>R; tattvayasamkhyo P<sub>2</sub>; tattvasamkhyo P<sub>1</sub>; tattvasamkhyo  
S    <sup>56</sup>bhāgā° P<sub>1</sub>    <sup>57</sup>yo P<sub>1</sub>S    <sup>58</sup>om. IV<sub>1</sub>; tatas P<sub>1</sub>S    <sup>59</sup>tayo P<sub>2</sub>    <sup>60</sup>om. RP<sub>2</sub>    <sup>61</sup>mukter IV<sub>1</sub>  
<sup>62</sup>kārah IV<sub>1</sub>P<sub>1</sub>    <sup>63</sup>maṇḍalā° P<sub>1</sub>    <sup>64</sup>sphuṭa- P<sub>1</sub>S    <sup>65</sup>kendra om. S

sā ca<sup>1</sup> ▷kaksāmaṇḍale<sup>2</sup> pariṇamyate<sup>3</sup> | tadartham uktaṃ<sup>5</sup> **phalaguṇitaṃ**<sup>6</sup> IV<sub>1</sub> 69v  
**vyāsārdham**<sup>7</sup> **vibhājayec**<sup>8</sup> **chīghrakarṇena**<sup>9</sup>(iti) traīrāsīkam idam<sup>10</sup> | tato<sup>11</sup>  
yal<sup>12</sup> labdham sā śīghrakendrabhuktiḥ sphuṭā<sup>13</sup> kaksāmaṇḍale<sup>14</sup> | sā ca<sup>15</sup> graha-  
śīghrasphuṭāgatyor<sup>16</sup> antaram | ata eva śīghragateḥ<sup>17</sup> saṃsodhya<sup>18</sup> ▷grahasya sphuṭā  
bhuktur<sup>19</sup> bhavati |

**labdham**<sup>20</sup> **adhikam cec**<sup>21</sup> **chīghragater**<sup>22</sup> yadā bhavati tadā viparītaśodhane  
kr̥te vakrabhuktur<sup>23</sup> bhavati yasmāc<sup>24</sup> chīghrakarṇas tadālpō<sup>25</sup> bhavati kaksāmaṇḍa-  
lasyoparisthitatvāt<sup>26</sup> | **phalaguṇitaṃ**<sup>27</sup> **vyāsārdham**<sup>28</sup> **vibhājayec**<sup>29</sup> **chīghra-**  
**karṇena**<sup>30</sup> yāvāt kriyate tāvac<sup>31</sup> chīghragater apy adhikā<sup>32</sup> śīghrakendrabhuktiḥ  
sphuṭā bhavati dr̥gbhedasyādhikatvāt | svamadyagateḥ<sup>33</sup> kaksāmaṇḍalāvasthiti-  
vaśena<sup>34</sup> graho 'pi ▷prāgdinādhyāsitaḥpradeśād<sup>35</sup> avalambitaḥ<sup>36</sup> paścād upalabhy-  
yate ▷śīghragatiśīghrakendrasphuṭabhuktyantareṇa | ata<sup>38</sup> uktaṃ **labdhāt**<sup>39</sup> **saṃ-**  
**sodhya śīghragatiṃ**<sup>40</sup> **vakragatir**<sup>41</sup> iti |  
sarvam upapannam<sup>42</sup> ||

### III.2 Translation

Now he tells two and half āryās for the correction of the daily motion of (the planets) beginning with Mars.

**One should divide by the first sine the daily motion of the śīghra of (the planets) beginning with Mars diminished by the daily motion (of the planet) corrected by its manda equation (and) multiplied by (the difference of) the sine(s) which is to be passed over by its śīghra equation. (Then) one should divide by the śīghra hypotenuse (of the planet) the radius multiplied by the result. The daily motion of the śīghra diminished by the result is the true daily motion (of the planet).**

<sup>1</sup>dya RP<sub>2</sub> <sup>2</sup>kakṣyā° RP<sub>2</sub> <sup>3</sup>pariṇāmyate S <sup>4</sup>between ▷ and ◁: °maṇḍalopari gamyate, °maṇḍalopari corrected to °maṇḍalepari by DY P<sub>1</sub>; <sup>5</sup>ukta IV<sub>1</sub>P<sub>2</sub> <sup>6</sup>phalā° corrected to phala° by DY P<sub>1</sub>; phalaguṇita- S <sup>7</sup>°dha P<sub>1</sub> <sup>8</sup>°jāye IV<sub>1</sub>RP<sub>1</sub> <sup>9</sup>chīkarṇam R; śī° P<sub>1</sub> <sup>10</sup>iti rtha R; ity artha P<sub>2</sub> <sup>11</sup>bhato RP<sub>2</sub> <sup>12</sup>ye tū P<sub>1</sub> <sup>13</sup>sphuṭa- IV<sub>1</sub> <sup>14</sup>kakṣyā° IV<sub>1</sub>RP<sub>2</sub> <sup>15</sup>va P<sub>2</sub> <sup>16</sup>°sphuṭātyor P<sub>2</sub>; °gatyoh P<sub>1</sub> <sup>17</sup>°gates I; °gate V<sub>1</sub>P<sub>1</sub> <sup>18</sup>samsodhya P<sub>1</sub> <sup>19</sup>between ▷ and ◁: grahasphuṭabhuktur IV<sub>1</sub>; grahasya sphuṭabhuktur P<sub>1</sub>S <sup>20</sup>°dhamm IV<sub>1</sub> <sup>21</sup>°ce IV<sub>1</sub>P<sub>1</sub>; cet RP<sub>2</sub> <sup>22</sup>śī° RP<sub>2</sub>; °gate P<sub>1</sub> <sup>23</sup>cakra° P<sub>2</sub> <sup>24</sup>°mā IV<sub>1</sub>R <sup>25</sup>tadā svalpo RP<sub>2</sub> <sup>26</sup>kakṣyā° IV<sub>1</sub>R <sup>27</sup>phalam guṇitaṃ P<sub>2</sub> <sup>28</sup>°dha S <sup>29</sup>°jāye IV<sub>1</sub>RP<sub>1</sub>; °jāyet P<sub>2</sub> <sup>30</sup>śī° P<sub>2</sub> <sup>31</sup>tāva IV<sub>1</sub>R <sup>32</sup>athādhikā for apy adhikā P<sub>1</sub> <sup>33</sup>°gate IV<sub>1</sub> <sup>34</sup>kakṣyāmaṇḍalapratiṇḍalāvasthi° (kaksā° P<sub>1</sub>S) IV<sub>1</sub>P<sub>1</sub>S <sup>35</sup>°dhyāsīpta° IV<sub>1</sub> <sup>36</sup>avilambitaḥ IV<sub>1</sub> <sup>37</sup>between ▷ and ◁: °deśāvalambitaḥ S <sup>38</sup>between ▷ and ◁: °bhuktyantaraguṇān IV<sub>1</sub>; °bhuktyāmtarenāta R; °bhuktyāramtarenāta P<sub>2</sub>; °bhuktyāmtaraguṇā ata P<sub>1</sub>; śīghragatiḥ | śīghrakendrasphuṭabhuktyantaraguṇā ata S <sup>39</sup>llabdhān IV<sub>1</sub>; labdhā R <sup>40</sup>°gati R; °gatir P<sub>1</sub>S <sup>41</sup>cakra° IV<sub>1</sub>RP<sub>2</sub> <sup>42</sup>for sarvam upapannam: sarvopapannam P<sub>1</sub>

**If the result is greater than the daily motion of the śīghra, when the daily motion of śīghra is subtracted from the result, a retrograde motion (is produced).**

Of what sort is the daily motion of the śīghra of the star-planets beginning with Mars? (It is) diminished by the daily motion (of the planet) corrected by its manda equation and multiplied by (the difference of) the sine(s) which is to be passed over by its śīghra equation. One should divide it when it is (thus). By what? **By the first sine.**

This is meant. Whatever is the daily motion of the planet beginning with Mars corrected by its manda equation (computed) by the calculation explained before, when it is subtracted from the daily motion of its śīghra, **the daily motion of the śīghra diminished by the daily motion (of the planet) corrected by its manda equation** is produced. Then one should multiply it by **(the difference of) the sine(s) which is to be passed over by its śīghra equation.** Whatever is the śīghra equation of the planet which is being corrected, the difference of the sines when the sine of that equation is being computed is the multiplier. That is called, **“(the difference of) the sine(s) which is to be passed over by its śīghra equation.”** Having multiplied by that **the daily motion of the śīghra diminished by the daily motion (of the planet) corrected by its manda equation, one should divide** (the product) **by the first sine,** that is, by 214.

Then whatever is the result, **one should divide by the śīghra hypotenuse (of the planet) the radius multiplied by that result.** Whatever is the result from that, **the daily motion of the śīghra** is always to be **diminished** by that. What is diminished is the true daily motion of the planet when it stands at that place.

**“If the result is greater than the daily motion of the śīghra”** (means) if what is obtained from the radius multiplied by the result and divided by the śīghra hypotenuse is greater than the daily motion of the śīghra, then, **when the daily motion is subtracted from what is obtained, the retrograde motion** is produced. When the reverse subtraction is made, the remainder is the retrograde motion. The meaning is that it is possible only at that time.

But in the case of Mars, there is this difference. When one has first computed the manda equation as mentioned, its half is subtracted from or added to the mean daily motion. Then one should divide by the first sine the daily motion of the śīghra diminished by that (and) multiplied by the sine of what is to be passed over by the śīghra equation. When one has derived the corrected daily motion by means of what was obtained as mentioned, half of the difference between that and the daily motion corrected by half of the manda equation is added to or subtracted from the daily motion computed by one calculation there; if the corrected daily motion is greater than the daily motion corrected by the manda (equation), it is added; otherwise, it

is subtracted. When it is computed in this way, the daily motion of Mars corrected by two calculations is produced. When one has assumed this to be the mean (daily motion, one should compute) the correction of the daily motion (of Mars) like (that of) the other planets. One should demonstrate everything after having set down (in a diagram) the orbit circle etc. properly.

Here is this explanation: At whatever place on the orbit circle is a planet corrected by the manda equation, when the center of the śīghra epicycle is computed to be there, the true planet is at the intersection of its (the epicycle's) circumference and the circumference of its śīghra eccentric circle. The distance between that and the line to its śīghra apogee increases every day by the difference between the daily motion of its śīghra and the daily motion of (the planet) corrected by the manda equation. Because the śīghra moves to the east by the daily motion of śīghra and (the planet) corrected by the manda (equation moves) by the daily motion corrected by the manda equation, therefore the daily motion of the śīghra diminished by the daily motion (of the planet) corrected by the manda (equation) is calculated. Whatever is the difference between these two is the daily motion of the śīghra anomaly. And that daily motion of the śīghra anomaly is corrected. There whatever rod passes the center of its śīghra epicycle, that is imagined to be the base line (*avadhi*) in the calculation of the arc of the equation. Because however great is the distance from that, so great is the equation of the planet, therefore the sine from that base line is produced in the calculation of the arc of the equation. Whatever that difference of the sines at the end of (the computation of) the śīghra equation is (that was) mentioned previously, there is the rule of three with that. If that difference of the sines is obtained by means of 225, then what is (obtained) by the minutes of the daily motion of the śīghra anomaly?

Then the second rule of three. If the minutes of an arc equal to 225 are produced by means of 214, then what is (produced) by means of the difference of the sines obtained (in the first rule of three)? Here, the number 225 is the divisor in the first rule of three and the multiplier in the second. Therefore, after removing these two, the difference of the sines is the multiplier of the daily motion of the śīghra anomaly and the first sine is its divisor. The result is the true daily motion of the śīghra anomaly at the place of the planet as it stands on the (śīghra) eccentric circle.

It is to be converted into (that) on the orbit circle. For that purpose this rule of three was mentioned: **“one should divide by the śīghra hypotenuse (of the planet) the radius multiplied by the result.”** Whatever is obtained from that, that is the true daily motion of the śīghra anomaly on the orbit circle. That is the difference between the true daily motion of the planet and that of the śīghra. Then, when one has subtracted (it) from the daily motion of the śīghra, the true daily motion of the planet is produced.

**If the result is greater than the daily motion of the śīghra**, then, after one has subtracted making subtraction in reverse, a retrograde motion is produced



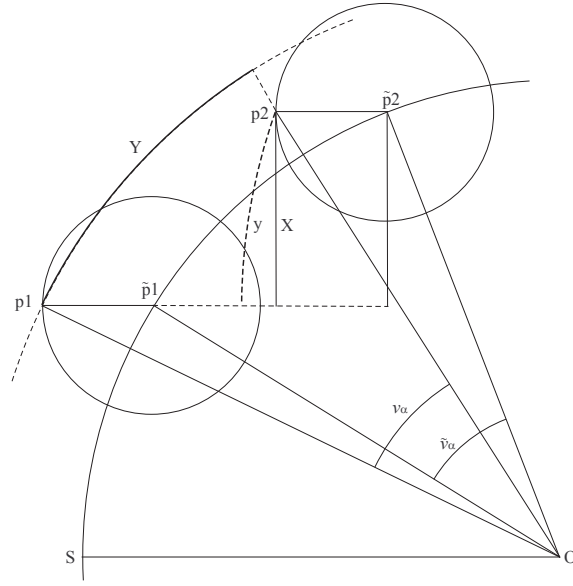


Figure 3:

because the śīghra hypotenuse is short at that time since the orbit circle stands above (the planet). **“One should divide by the śīghra hypotenuse (of the planet) the radius multiplied by the result”** is (the rule) as long as the true daily motion of the śīghra anomaly is greater than the daily motion of the śīghra since the observational difference (*dr̥gbheda*) is greater. Because of the fact that its mean motion belongs to its orbit circle, the planet is understood to slip westwards from the position which it occupied on the previous day by the difference between the daily motion of the śīghra and the true daily motion of the śīghra anomaly. Therefore it is said that **“when the daily motion of śīghra is subtracted from the result, a retrograde motion (is produced).”**

Everything has been explained.

### III.3 Mathematical Commentary

This rule is utilized in BSS for applying śīghra equation to the manda-corrected motion<sup>2)</sup>. The mathematical expression of this rule is<sup>3)</sup>:

$$v = v_S - (v_S - \tilde{v}) \cdot \frac{\Delta J_\alpha}{J[1]} \cdot \frac{R}{H},$$

where

$v$ : the true daily motion of the planet

$v_S$ : the daily motion of the śīghra apogee

$\tilde{v}$ : the manda-corrected daily motion of the planet

$R$ : the radius of the standard circle ( $O\tilde{p}_1$  in figure 3)

$H$ : the true geocentric distance of the planet ( $Op_1$ ).

Pr̥thūdaka explains this rule by means of three proportions. (figure 3). In this figure  $\tilde{p}_1$  and  $\tilde{p}_2$  stand for manda-corrected planets in two successive days and  $p_1$  and  $p_2$  for the true planets. Śīghra apogee (S) which moves faster than the planet is fixed here, so that the planet looks as if it moves backward by the daily motion of śīghra anomaly ( $v_\alpha$  and  $\tilde{v}_\alpha$ ).

The first proportion is the common proportion to get Rsine-differences:

$$I : \Delta J_\alpha = \tilde{v}_\alpha : X.$$

By this proportion,  $X$ , i.e., Rsine-difference corresponding to the manda-corrected daily motion of anomaly  $\tilde{v}_\alpha$  is obtained.

Then Pr̥thūdaka applies the second proportion to  $X$ :

$$J[1] : I = X : y,$$

where  $y$  is the arc expressed in a dashed bold line starting from  $\tilde{p}_2$ . Pr̥thūdaka says that this  $y$  is “the true daily motion of the śīghra anomaly at the place of the planet as it stands on the (śīghra) eccentric circle.” Gathering from this comment and the third proportion, Pr̥thūdaka seems to assume  $y$  to be the arc  $Y$ , which is expressed in a bold line beginning from  $p_1$ . Actually this is a good approximation when the śīghra anomaly is close to  $0^\circ$  ( $360^\circ$ ) or  $180^\circ$ .

Then he reduces  $Y$  to the arc on the orbit circle, i.e., the true daily motion of the anomaly  $v_\alpha$ , by means of the third proportion:

$$H : R = Y : v_\alpha.$$

When these three proportions are combined, we get a rule for calculating  $v_\alpha$ :

$$v_\alpha = \tilde{v}_\alpha \frac{\Delta J_\alpha}{J[1]} \cdot \frac{R}{H}.$$

Then, since

$$v = v_S - v_\alpha, \quad \tilde{v}_\alpha = v_S - \tilde{v},$$

we finally get Brahmagupta’s formula:

$$v = v_S - (v_S - \tilde{v}) \cdot \frac{\Delta J_\alpha}{J[1]} \cdot \frac{R}{H}.$$

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## Notes

<sup>1)</sup>Similar rules appear in: PS IX 12–14ab; MBh IV 14–17, IV 58–59; LBh II 9–13; KhKh I 19–20; SDV II 15, III 11–13; SS II 47–49; VS II i 97–98, II i 100; and SSE III 40–41. These all are discussed in Ikeyama forthcoming. This rule is criticized in LBh II 14–15 and SDV III 16.

<sup>2)</sup>The followers of this rule are not many. We can see similar rules only in SDV III 18cd–19; VS II iii 18; and SSE III 42–43. Bhāskara criticized this rule in SSI I 2, 40 and gives an improvement in SSI I 2, 39. See Ikeyama forthcoming for more information.

<sup>3)</sup>According to Dvivedin’s edition (and Sharma’s 1966 edition), this rule can be expressed:

$$v = v_S - \text{śighra equation} \cdot \frac{\Delta J_\alpha}{J[1]} \cdot \frac{R}{H}$$

which is difficult to rationalize.

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