SOME OBSERVATIONS ON *VṚDDHA-VAŚIṢṬHA SIDDHĀNTA*

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(*Received 16 April 1975*)

From a study of the revolution numbers of the node and the apogee of the moon as given in *Vṛddha vaśiṣṭha Siddhānta*, the *Vaṭeśvara Siddhānta* and the *Karaṇa Tilaka*, it has been suggested that the astronomical knowledge contained in the *Sūrya Siddhānta* was revised in at least two stages. The first revision took place a little earlier than A.D. 900 and the second in about A.D. 1100. An ingeneous method of calculating *ahargaṇa* given in *Vṛddha-vaśiṣṭha Siddhānta* has also been discussed and an error in the *jyā* value of 60° given in it has been pointed out.

The astronomical knowledge contained in the *Vṛddha-vaśiṣṭha Siddhānta* has been very largely influenced by the *Sūrya Siddhānta*. In stanzas 24 to 32 of the *Madhyamādhikāra* it gives the different astronomical constants for calculating the mean places of the planets, their *śīghroccas*, the node and the apogee of the moon and the *ahargaṇa* and states the number of the revolutions of the stars. These are the same as those given by the modern *Sūrya Siddhānta*. In particular in stanza 28, it states that the revolution numbers of the apogee and the node of the moon are respectively 488203 and 232238. Then in stanzas 33 to 36 it states the number of times that the different planets, their *śīghroccas* and the apogee and the node of the moon rise in the east. It is easy to see that these numbers, in all cases except the node of the moon which has a retrograde motion, will be equal to the differences between the revolution number of the stars and the revolution numbers of the respective planets etc. This has specifically been stated indirectly in the first half of stanza 37 which says that the difference between the reovolution number of the stars and the number of rising is equal to the revolution number. But the retrograde motion of the node of the moon has not been taken into account in stating its rising number though in the *Brahma Siddhānta*, which also gives exactly the same constants, it is clearly stated that in the case of nodes their revolution numbers should be added to the revolution number of the stars to get their rising number.[1]

The rising numbers of the apogee and the node of the moon have been stated in stanza 36 as 1581749617 and 1582005594 and if we subtract these numbers from the revolution number of the stars, viz. 1582237828, the numbers obtained are 488211 and 232234. But these are different from the revolution numbers of the apogee and the node of the moon stated earlier. In this connection we must consider the astronomical constants as stated by Vijainandin of Varanasi who composed

his *Karaṇa-tilaka* in śaka 888. The original of this book is lost but an Arabic translation by al-Bīrūnī is available. This has been translated into English by S. Samad Husain Rizvi.[2] Vijainandin does not state the revolution numbers but from the methods which he has given for calculating the mean places of the planets, it is possible to calculate back the revolution numbers. These are the name as given in modern *Sūrya Siddhānta* except the revolution numbers of the apogee and the node of the moon. These latter are respectively 488211 and 232234.

Again if we examine the revolution numbers of the apogee and the node of the moon as given by Vaṭeśvara we are confronted with a contradiction similar to *Vṛddha-Vaśiṣṭha Siddhānta.* In stanza 14 of the first chapter, *Vaṭeśvara Siddhānta* gives these values as 488203 and 232238, i.e. the same as in the present *Sūrya Siddhānta.* But later in the chapter on *Pratyabda śuddhi*, stanza 13 gives the annual motions of the apogee and the node of the moon as $40° 41\frac{11'}{200}$ and $29° 21\frac{34'}{100}$ respectively. These when multiplied by 4,320,000 give the numbers of revolutions of the apogee and the node as 488211 and 232234 which are the same as those given in *karaṇa-tilaka.*

Again later in stanzas 19, 20 and $20\frac{1}{2}$ of the same chapter the annual motions have been stated in another manner. But these stanzas are very corrupt. The second half of the first line of stanza 19 is the same as the second half of the first line of stanza 20. But from the first half of the first line and the second line of 19, it appears that the motion is given by $\frac{S}{9} + \frac{X.S}{1440000}$, where S is the motion of the sun. If we take S to be the motion of the sun in a *yuga*, the motion of the apogee in a *yuga* comes out as $480000+3X$. Hence the revolution number of the apogee of the moon must be such that on subtractng 480000 from it the remainder should be divisible by 3. Now 8211 is divisible by 3 but 8203 is not divisible by 3. It therefore appears that the Vaṭeśvara's original value of the revolution number of the apogee of the moon was 488211 which was later changed to 488203 by some copyist in the first chapter but not in the latter chapter.

Stanza 19 may therefore be restored to read as

ravinavabhāge yojyaṃ nagāgnisaptāśvitāḍitādbhānoḥ
khacatuṣṭayavedendrairhimgūccaṃ vā bhavatyevaṃ

The first line of 20 has to be combined with the first line of 21 to give the motion of the node. It states that the motion of the node is given by

$$\frac{S}{20} + \frac{8117S}{2160000}$$

Here again if we put $S=4,320,000$ the revolution of the number of the node comes out to be 232234 which was later changed to 232238 in the first chapter.

Here we must remember that Vaṭeśvara was born in Śaka 802 and wrote his *Siddhānta* at the age of twenty-four years.[3] Vaṭeśvara therefore is slightly earlier than Vijainandin but they are very nearly contemporary. It seems therefore that the astronomers found that the astronomical constants stated in the old *Sūrya Siddhānta* of Varāhamihira did not give correct results and they changed them. The first revision seems to have been effected in about A.D. 900 when the revolution number of the apogee of the moon was reduced to 488211 and that of its node was increased to 232234. This is the stage represented by Vaṭeśvara, Vijainandin and the rising numbers of *Vṛddhavaśiṣṭha Siddhānta*. It was at this time that the number of civil days in a *yuga* was changed from 1577917800 to 1577917828. In the next revision of the constants, they were changed to their present values stated in the *Sūrya Siddhānta*. They were incorporated in stanza 28 of the first chapter of the *Vṛddha-vaśiṣṭha Siddhānta* and stanza 14 of *Vaṭeśvara Siddhānta* but have not been incorporated in other places. There have been changes in other constants also. These have been shown in Table 1. The revolution numbers of the sun and moon have not been included as there is no change in them.

TABLE 1

Revolutions in a *yuga*.

	Old *Sūrya Siddhānta*	*Āryabhaṭīya* (A.D. 500)	Vaṭeśvara (śaka 826)	*Karaṇa-tilaka* (Śaka 888)	Modern *S.S.* (*C.* A.D. 1100)	*Makaranda Sārani* (16th Cent.)
Mars	2,296,824	2,296,824	2,296,828	2,296,832	2,296,832	2,296,832
Śīghrocca of Mercury	17,937,000	17,937,020	17,937,056	17,937,060	17,937,060	17,937,044
Jupiter	364,220	364,224	364,220	364,220	364,220	364,212
Śīghrocca of Venus	7,022,388	7,022,388	7,022,376	7,022,376	7,022,376	7,022,364
Saturn	146,564	146,564	146,568	146,568	146,568	164,580
Apogee of Moon	488,219	488,219	488,211	488,211	488,203	488,199
Node of Moon	232,226	232,226	232,234	232,234	232,238	232,242

In stanza 46 of the first chapter *Vṛddha-vaśiṣṭha Siddhānta* is given an ingeneous short method of calculating the *ahargaṇa*. It says : Put the solar years multiplied by 12 in four places ; in one place divide it by 1532 and subtract the quotient from the number in the second place ; divide the result by 70 and add the quotient to the number in the third place ; divide the result by 33 and add the quotient to the number in the fourth place ; the result is the number of lunar months. Multiply the lunar months by 30 and again by 11 and put the result in two places ; divide

the number in one place by 99216 and subtract the quotient from the number in the second place ; divide the result by 703 and you get the *avama* days which subtracted from the lunar days gives the *ahargaṇa* in *sāvana* units.

The method of obtaining the *avama* days is similar to that of Brahmagupta stated in *Khaṇḍakhādyaka*.[4] Only the first divisor is different because the number of *avama* days in a *yuga* is not the same in the two cases. We will therefore discuss only the rationale of obtaining the number of *adhimāsa* months. The number of *adhimāsa* months in a *yuga* according to *Sūrya Siddhānta* is 1,593,336. Hence the number of *adhimāsa* months in S solar months is given by

$$A = \frac{1{,}593{,}336 \times S}{51{,}840{,}000} = \frac{66{,}389 \times S}{2{,}160{,}000} = \frac{S}{33 - \frac{30837}{66389}} = \frac{S+Y}{33}.$$

$$\therefore \quad Y = \frac{33 \times S}{33 - \frac{30837}{66389}} - S = \frac{30837 \times S}{2{,}160{,}000} = \frac{S}{70\ \frac{1410}{30837}} = \frac{S-Z}{70}$$

$$\therefore \quad Z = S - \frac{70 \times S}{70 + \frac{1410}{30837}} = \frac{1410 \times S}{2{,}160{,}000} = \frac{S}{1531.9149} \simeq \frac{S}{1532}.$$

$$\therefore \quad Y = \frac{S\left(1 - \frac{1}{1532}\right)}{70}.$$

$$\therefore \quad \text{and } A = \frac{1}{33}\left[S + \frac{S\left(1 - \frac{1}{1532}\right)}{70}\right].$$

In stanzas 9 to 10 ½ of the second chapter *Vṛddha-vaśiṣṭha Siddhānta* gives the *jyā* and *utkramajyā* values of nine angles at intervals of 20°. These are shown in table II. The table also contains the *jyā* values deducible from (*a*) Āryabhaṭa's *jyā* table, (*b*) BhāskaraI's short formula (*c*) Vaṭeśvara's table and (*d*) true sine values. The first point to be noticed is that the *jyā* value for 60° is not correctly stated in the printed book. This is evident from the fact that *jyā* 60°+*utkramajyā* 30° should be equal to 1000. Since in the table *utkramajyā* 30° is 134, *jyā* 60° should be 866. After this correction is made it is observed that (*i*) the *jyā* values are quite accourate and (*ii*) they have not been deduced from Āryabhaṭa's *jyā* values or the short formula of Bhāskara I. A similar comparison with *jyā* values deducible from Brahmagupta's tables shows that the values are not based on Brahmagupta's table also. They may have been deduced from Vaṭeśvara's values or obtained independently.

TABLE 2

Jyā and *utkramajyā* values

Angle	*jyā*	*Utkramajyā*	The same deduced from Āryabhaṭa *jyās*	Deduced from formula of Bhāskara I	Deduced from Vaṭeśvara *jyās*	True values
10	174	15	173.65	175.26	173.84	173.65
20	342	60	341.77	343.16	342.01	342.02
30	500	134	500.00	500.00	500.00	500.00
40	643	234	642.52	641.83	642.77	642.79
50	766	357	765.76	764.71	766.02	766.04
60	868	500	866.20	864.86	866.03	866.03
70	940	658	939.40	939.02	939.66	939.69
80	985	826	984.44	984.62	984.78	984.81
90	1000	1000	1000.00	1000.00	1000.00	1000.00

References

[1] *Brahmasiddhānta*, ed. by Vindhyesvari Prasad Dvivedi, Varanasi, 1912, I.71.

[2] S. Samad Husain Rizvi, I.C., Vol. 37 (1963), p. 112, p. 167, p. 223 ; Vol. 38, (1964), p. 47, 195 ; Vol. 39, (1965), p. 1, p. 137.

[3] *Vaṭeśvara Siddhānta*, ed. R.S. Sharma et al ; New Delhi, 1962, *Madhyamādhikāra*, I. 21.

[4] *Khaṇḍakhādyaka*, ed. and trans. Bina Chatterjee, Calcutta, 1970, I.3-5.

[5] *Mahābhāskarīya*, ed. and trans. K. S. Shukla, Lucknow, 1960, VII. 17-19.