

THE EPOCH OF THE ROMAKA SIDDHĀNTA IN THE PAÑCA
SIDDHĀNTIKĀ, AND THE EPOCH LONGITUDES OF THE SUN
AND MOON IN THE VĀŚISTHA—PAULIŚA

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A. ROMAKA EPOCH

Varāhamihira (VM) gives in chap. 18 of his *Pañcasiddhāntikā* (*PS*) the Epoch of the *Romaka Siddhānta* as mean sunset at Yavanapura (Alexandria in Egypt) ending Sunday and beginning Monday, close to the beginning of the Hindu *Caitra Śukla* of śaka 427 elapsed, equivalent to 6 p. m. local mean time at Alexandria on the Julian Sunday 20th March, 505 A. D. He says this is the Epoch of the *Pauliśa Siddhānta* as well. Since in III, 13 he says that the local mean time at Avanti (Ujjain) is 7-20 *nāḍis* in advance of that of Yavanapura, the moment of the Epoch is 37-20 *nadis* from mean sunrise at Ujjain on Sunday 20th March, 505 A. D. Thibaut and Sudhakara-dvivedi (TS) the first editors of the *PS* agree with this. But Neugebauer and Pingree (NP) in their edition of *PS* (Kobenhavn 1970, 1971) say (Part I, p.8) that it is one day later, i.e. Yavanapura, Monday/Tuesday, equal to 6 p.m. 21st March. This is wrong, and I shall show in this paper that the Sunday/Monday, one day earlier, is the Epoch.

The matter can be clinched by comparing the mean new moon of the *Romaka* with those of the other *Siddhāntas* and modern astronomy. They should be reasonably near each other. Since the *tithi* is independent of the origin, the new moon is eminently fit for comparison. VM says that the *Romaka tithi* is tolerably accurate. The epoch constants of I, 9-10, can also be used to check the agreement.

The following table gives the mean sun and moon at 37-20 *nāḍis* from mean sunrise at Ujjain on Sunday 20th March, 505 AD (corresponding to sunset at Yavanapura, Sunday/Monday) according to various *Siddhāntas*, and modern astronomy. The modern values are tropical, but since the *Ayanāmsā* (precession) is near zero and the *tithi* is independent of the origin, this will not affect the result. The *Kali*-days of the point taken is 1,317, 122-37-20

days from the first day of mean *Kali*, i.e. Friday mean sunrise at Ujjain, 18th February 3102 B.C.

The Julian days of this point is 1,905, 588-9-43. The titles of the columns I to III are I, Modern Astronomy (Newcombe, Brown) II, *Brāhmasphuṭasiddhānta*, and *Siddhānta Śīromaṇi*, III, Modern *Sūryasiddhānta*, *Āryabhaṭīya*, and the *Sūryasiddhānta* of *PS*. Columns IV to VII are for the *Romaka* at 37-20 *nāḍis*, at Ujjain on Epoch day; IV if the moon's constant is 1984, given for Ujjain sun-set, V if the moon's constant is 1984 for Ujjain at 37-20 *nāḍis*, VI, the constant 10984 given for Ujjain at sunset, VII the constant 10984 given for Ujjain at 37-20 *nāḍis*.

	I	II	III	IV	V	VI	VII
Mean Sun	359°37'	0°42'	359°49'	359°42'	359°34'	359°42'	359°34'
Mean Moon	354°48'	355°49'	355°6'	0°56'	359°19'	357°49'	356°12'
Moon—Sun	-4°49'	-4°53'	-4°43'	+1°14'	-0°15'	-1°53'	-3°22'
Moment of New Moon (in <i>nāḍis</i>)	23—41 later	24—0 later	23—11 later	6—4 earlier	1—15 later	9—11 later	16—33 later
Beginning of Mean Solar Year (in <i>nāḍis</i>)	23 later	43 earlier	11 later	18 later	26 later	18 later	26 later

The following must be noted: (1) The positions of the sun and moon are apparently greater by about one degree in the *Brāhmasphuṭa* and *Siddhānta Śīromaṇi* because these take the tropical zero-point about 100 years later (c. 628 A.D.) as the zero-point of *Meṣa Rāśi*. But, as we have already said this will not affect our investigation.

2. The constants for the sun and moon in IX, 1, 2 are taken for mean noon at Ujjain on Sunday 20th March, 505 A.D. This agrees with the *Khaṇḍakhādya*. (3) Columns II and III exhaust all main classical *siddhāntic* schools. The *Vāsiṣṭha* and *Pauliṣa* will be treated separately.

We see from these tables that the new moons of all the classical *siddhāntas* and modern astronomy fall within one *nāḍi* of one another, showing their accuracy. Their moments are 23 to 24 *nāḍis* after the time taken. Since the classical group includes the *Sūryasiddhānta* of *PS*, the point of the time taken, Yavanapura sunset at Sunday/Monday, is the epoch. Now the *Romaka*, described as nearly correct compared to the *Pauliṣa* and *Sūrya* in its *tithi* (Cf. *PS* 1,4), must have its new moon also near other new moons, though not very close. We must rule out its falling, say about 30 *nāḍis* earlier or later, which can be due to a mistake in the epoch data given. There is a doubt about the time of day for which *Romaka* constants of the sun and moon are given. Is it 37-20 *nāḍis* after Ujjain sunrise (sunset at Yavanapura) as normally it

should be? Or is it sunset at Ujjain (7-20 *nāḍis* earlier), taking the time for the constant of the moon's anomaly given in VIII, 5 for these also? Columns IV and V of the table give the results of the two cases. Both are unsatisfactory. In the former case, if Sun/Mon is the Epoch, new moon falls 1-15 *nāḍis* later than the point of time, about 22 *nāḍis* earlier than the rest. In the latter, new moon falls 6-4 *nāḍis* earlier than the point of time, 29 *nāḍis* earlier than the others. If Mon/Tues is taken as epoch, in the former case new moon falls about 38 *nāḍis* later, and in the latter about 30 *nāḍis* later. Both are unsatisfactory and so the constants must be wrong.

There is fair agreement between the *Romaka* mean sun and that of the others. But the mean moon differs by several degrees if the constant is taken as 1984 (*Kṛtāṣṭanavakaika*). By emending the word into *Kṛtāṣṭanavakhaika*, we get the constant as 10984. With this constant, given for Ujjain sunset, we get 357°49' for the mean moon, and 356°12' if it is given for Ujjain 37-20 *nāḍis*, i.e. at the epoch time of day. The former gives the new moon 9-11 *nāḍis* later, while the latter gives the new moon 16-33 *nāḍis* later, as close as 7 *nāḍis* from the rest. This is the best we can get. If the epoch is taken as Mon/Tues, these, two new moon moments will be 46 *nāḍis* and 53 *nāḍis* later. Hence the epoch day is Sun/Mon.

This new moon, coming 16-33 *nāḍis* after zero, Sun/Mon, agrees with the statement *Caitra śuklādau*, the absence of the constant for *adhimāsa*, and the constant 514 given for *avama*. The sun being at 359°34', the solar year begins after 26 *nāḍis*, i.e. about 9-30 *nāḍis* from new moon, for which the *adhimāsa* constant will be as small as one, and is therefore neglected in I,9. It is also the beginning of *Caitra* as stated. If the new moon is taken to the next day, 50 *nāḍis* in the new solar year would have passed, the new moon would initiate the *adhikavaiśākha*, and the *adhi* constant would be as large as 222, disagreeing with the above instruction. These confirm the Sun/Mon epoch. As for the *Avama* constant 514, it represents an *avamaśeṣa* 43-52 *nāḍis* giving the end of new moon as 16-8 *nāḍis* from epoch*, which agrees fairly well with the 16-35 *nāḍis* got after Sun/Mon.

All these show that the epoch is Sun/Mon and not Mon/Tues. (The *Vāsiṣṭha-Paulīśa* constants also give this result, as we shall show later). This is confirmed by I, 17-20, which gives the Lords of the *sāvana* year, month and day. At the moment of epoch (i.e. zero day gone) we have to work with $2227+0=2227$. Dividing by 2520, the remainder is 2227. Dividing this by 7, the remainder is 1. The instruction is that the Lords are to be counted from

* cf. *Sid. Śir. Gola, madhya. 16 b. 18a. 'darśāgratassamkrama kālataḥprāk sadaivatisthaya dhimāsaśeṣam/tithyan tasūryodayayostu madhyesadaiva tisthaya vāmā vāśeṣam|*

the Sun (I, 19). So we get, Sunday ending at Zero Epoch, and the next day beginning is Monday. So the Epoch is Sun/Mon. Now, In part II, p. 14 NP add one to 2227 to get the Lord of the *first day after Zero Epoch*, and dividing out 2228 by 7, get remainder 2 all right, which is correctly Monday, counting from Sunday as one. But they mistake it to be Tuesday, and incorrectly take Mon/Tues to be the Epoch.*

Now we come to the actual day mentioned in I, 8. The reading of α is 'saumya divasādye', that of β is 'bhaumya divasādye'. Bhaṭṭotpala's reading is 'somadivasādye'. It is this reading meaning "beginning Monday" that is correct. But NP discredit it as one likely to have been emended by Sudhākara Dvivedi in his edition. Whatever it is, the discussion in this paper shows that it is correct. The word "saumya" also can be taken to mean Monday. It has two meanings, (1) "the son of Moon", i.e. Budha. If this is taken it would denote Wednesday, which is two days later and obviously wrong; (2) "related to Moon", i.e. moon's day, i.e. Monday. The reading 'bhaumya' is in the far worse vitiated manuscript β , and a corrupt form of 'saumya'. Further 'bhaumya' is meaningless, and has to be corrected into 'bhauma' to mean Tuesday.

The emendation into 'bhauma' is due to Dikshit. In Part I p. 18 NP say : "Dikshit concludes that the Epoch of VM is Tuesday 22nd March, 505, but that according to the *Sūryasiddhānta*, the *kṣepakas* (epoch constants) in IX, 1-4 are for the noon of Sunday 20th March, and the *kṣepakas* in XVI 10-11 are for midnight 20/21 March in the same year. The *kṣepakas* in VIII, 1,4-5,8 are computed for sun-set of 20th March 505, and this is not the epoch of the original *Romaka Siddhānta*, which he claims was written between the time of Hipparchus and A.D. 150". Now, the days for computing are from the zero day of Epoch, which is precisely the time of the Epoch, and the *kṣepakas* also are for the time of Epoch. So according to these statements of Dikshit himself, the *Romaka* Epoch is sunset, Sunday 20th March, near Yavanapura sunset, ending Sunday, beginning Monday, for the Julian date 20th March. Similarly the *Sūryasiddhānta* Epoch for the sun and moon is Ujjain noon on the same Sunday, 22 *nādis* before the *Romaka* Epoch, and the Epoch for the star planets in XVI is 8 *nādis* later than the *Romaka* Epoch, which is the Julian Sun 20/Mon 21, March. Then, how could Dikshit say that the Epoch is Tuesday 22nd, when the purpose of the Epoch is only to give the beginning of the time to be taken in a computation? To compute modern values for comparison, NP

* Though it is irrelevant for our purpose here, I shall clarify one point. In the footnote on p. 13 NP are correct in observing that the rule for Lord of the month as given in verse, I, 19 is wrong, but their suggestion to correct it will not serve the purpose. "Subtract one" is the additional instruction required there, as given by Bhaṭṭotpala's reading ... 'vyekāḥ' for 'kāryāḥ'.

go even to 5 PM Tuesday 22nd March, one day later than the Epoch they themselves have fixed, and two days later than the correct *Romaka* Epoch.

Thus Sun/Mon is the Epoch. As already mentioned, the constants of the *Vāsiṣṭha-Pauliṣa*, and *Sūryasiddhānta* (in XVI), also agree with this.

B. THE EPOCH LONGITUDE OF THE SUN AND MOON IN THE *Vāsiṣṭha-Pauliṣa*

In II, 1 the sun's Epoch constant is given by '*yaṣamamṛtuyuta*' corrected into '*mṛtuyuta*' and thus taking +6. This verse gives the true sun. So the true sun at Epoch is $(0 \times 4 + 6) \times 30^\circ/127 = 1^\circ 25'$. Since on examination we see that the apogee falls near the middle of *Mithunā*, we may roughly take the equation of the centre at the beginning of *Meṣa* to be $2^\circ 10'$, (the maximum being = $135'$) and subtracting this from the true sun, the mean sun is $359^\circ 15'$ at Epoch.

The mean moon at Epoch can be got from the constant +1936 days, given in II 2. The days to work with is Epoch days +1936 = 0 + 1936 = 1936. The mean moon = the mean motion in 1936 days + a constant (II, 2-4) = $309^\circ 25' + 1^\circ - 14^\circ - 29' * = 353^\circ 54'$. Obviously this constant is the mean moon at the point 1936 days before epoch. This is only $54'$ less than the modern, given in the table, and need not be ascribed even to the error of the *siddhāntas* (its mean motion being remarkably equal to the modern) but to its first point being forward, by this amount, from the first point of τ (i.e. the vernal equinox) of 505 A.D. as it should be about 60 years earlier. (Its mean sun at Epoch, $359^\circ 15'$, confirms this idea.) Mean sun—mean moon being $5^\circ 21'$, the new moon falls 21-18 *nāḍis* later than the epoch time, and if it should fall in line even approximately with the other *siddhāntas* and the modern, the Epoch itself should be Sun/Mon. Since the *Vāsiṣṭha* moon is the same as the *Pauliṣa*, the Epoch constants of the *Pauliṣa* got from I, II and III. 1-3 should confirm this, and they do, as we shall see.

In part II p. 22 NP go back 1936 days from 5 p. m. 22nd March 505 A.D. arriving at Dec 3, 499, and state that the mean moon of that day at

* We get $1^\circ 14' 29'$ by emending "*muni*" in "*śaśimuni nava yamāśca rāśyādyāh*" into "*manu*". Then the moon and new moon agree reasonably with those of the other *Siddhāntas* (Cf. the Table above). As it is, the moon will be less by 7° , and therefore 8° less than the modern value if the epoch is Sun/Mon and 21° less if it is Mon/Tues. This would mean that the new moon would be later by 40 *nāḍis* and 105 *nāḍis* respectively, which is impossible. In an earlier paper (*Vāsiṣṭha* sun and moon in the *PS*, K. S. Research Institute, Madras, 1958) I was not willing to amend even obvious errors, concluding that the *Vāsiṣṭha* moon must have been given for sunrise at Ujjain. But in the absence of any special instruction to that effect, only the Epoch time should be normally taken. So later I emended "*muni*" into "*manu*", which gives such good agreement.

5 p. m. at Ujjain is $2^{\circ} 9' 20''$. This being $\approx 2^{\circ} 9' 7''$ (the constant given in this text by '*śaśimūninavayamāscarāśyādyāḥ*') they say that the 5 p. m. 22nd March, and the constant given, are verified at one stroke. But the 5 p. m. 22nd March is nearly one day later than the Epoch they fix, namely Mon/Tues Ujjain 37-20 *nādis* on 21st March. This new Epoch is given no where in the text of *Vāsiṣṭha* or *Pauliśa*. The following is their mistake : The correct date to go back is Dec. 1st 499, 6 p. m., Ujjain, and at that time the mean moon is nearly $1^{\circ} 15' 23''$ by modern astronomy. This is only one degree off the emended text value $1^{\circ} 14' 29''$, which error can be reasonably attributed to the *Siddhānta*. It should be noted that the apparent agreement brought about by NP is due to two mistakes made by them, one equal to the other. First there is the two days error of about 26° mentioned above. Secondly, they have interpreted "*śaśimūninavayamāsrāśyādyāḥ*" as $2^{\circ} 9' 7''$, not paying attention to the word '*rāśis*' etc" The correct value, as given by the emended text is $1^{\circ} 14' 29''$. So the error here is nearly 25° . (cf. the previous footnote).

Next we take the *Pauliśa*. Since no separate instruction is given, the new moon is the same as the *Vāsiṣṭha*. To fix the mean sun at Epoch without any doubt, the whole of III, 1-3, giving the true sun must be studied, since these verses have not been understood by TS or NP. Like the *Vāsiṣṭha*, the *Pauliśa* also begins with giving what is actually the true sun at the beginning of the year, and calling it the mean sun. Therefore, the equation of the centre at the beginning of the year, about $2^{\circ} 13'.5$ minus the $7'$ got by the instruction to subtract $11' \times 20/30$, equal to $2^{\circ} 6'.5$ is included in the so-called mean sun. I shall translate the verses III, 1-3.*

III 1. Multiply the days from Epoch by 120, subtract 33, and divide by 43831. The revolutions etc. of the mean sun is got. This, plus 20° is the *kendram* (i.e. anomaly, but here used in the sense of the argument to be used).

III 2.3. For each *rāśi* of *Kendram*, subtract continuously, one for one, $11'$, $48'$, $69'$, $70'$, $54'$, $25'$, and then add $10'$, $48'$, $70'$, $71'$, $54'$ and $25'$. The mean sun becomes true.

This straight interpretation gives clearly the method of computation. Example : Let the days from Epoch be 620. Then $(120 \times 620 - 33)/43831 = 1$ rev. $8^{\circ} 10' 52''$. This plus 20° gives $9^{\circ} 0' 52''$ as the *kendram*. So the true sun = $8^{\circ} 10' 52'' - 11' - 48' - 69' - 70' - 54' - 25' + 10' + 48' + 70' + 2'$ (the last term for the $52''$ left over) = $8^{\circ} 8' 25''$. (This is similar to the method of the *Vākyakaraṇam*).

* This was given as item 1 of a paper by me in the *Vishveshvaranand Indological Journal*, Hoshiarpur, 1973, first presented at the World Sanskrit Conference, 1972.

I pointed out TS's mistakes in the paper mentioned in the previous footnote. I subsequently found that in their edition (Part II p. 21) NP have improved upon TS's translation, but have made a great mistake in concluding that the sun's maximum equation of the centre to be 72'. This is due to their mistaking the 11', 48' etc. as actual values, instead of differences, of the equation of the centre and that the anomalies taken are 290° onwards. But actually the apogee is taken to fall at 70°, i. e. 10° Gemini, not at 80° (i.e. 20° Gemini) as they say. The 70° may appear to be quite wrong, but it may be the relic of a very early period when the vernal equinox was forward by about 5° (the equivalent of 360 years). This shifting of the first point backwards, together with the actual small movement of the apogee, could have been the reason for taking the differences as -11', -48', etc instead of the correct original differences for 270°, 300° etc, namely -19', -51' -70', -70' -51', -19'. +19' +51' +70', +70', +51', +19'.

On this basis, we can fix the mean sun of the *Paulīśa* at zero day Epoch. The so-called "mean sun" is $(0 \times 120 - 33) / 4383' = -16'.5$. This contains the equation of the centre of that point, 133'.5 less the 7' got by computation, i. e. 126'.5. The real mean sun at Epoch is $-16'.5 - 126'.5 = -2^\circ 23' = 357^\circ 37'$ * The mean sun will reach zero *Meṣa* 2 days 25 *nāḍis* later than the Epoch. Mean Sun—Mean moon = $357^\circ 37' - 353^\circ 54' = 3^\circ 43'$. So the new moon occurs 18-17 *nāḍis* later than the Epoch. This is 5 *nāḍis* before the classical and modern new moon, and closer than the *Romaka*. The days corresponding to the *adhimāsaśeṣa* are from mean new moon to mean zero point of *Meṣa* 2 days 6 *nāḍis* 43 *vināḍis*.

That these findings are correct will be confirmed by the *kṣepas* (constants) for *adhimāsa* and *avama*, in I. 11, according to the *Paulīśa*. The former is 698, giving 698/9761 of a lunar month, nearly equal to the 2 days 6 *nāḍis* 43 *vināḍis* found above.

The *avama* constant is given by the last foot, both mss. combined giving the reading, *trikṛtadinānyavamakṣepaḥ*. '*trikṛta*' is corrupt, as taken by all. So, whatever is given by '*trikṛta*', that is the *avama* constant given. I emend it into '*vikṛtakṛtāny*' and take it to mean "the *avamakṣepa* is less (than the *Kṣepa* given before, i. e. 698) by 44'. So the *avamakṣepa* is 654. This gives very nearly 41-43 *nāḍis*, which subtracted from 60 *nāḍis* gives nearly 18-17 *nāḍis* as the time of new moon after epoch, giving perfect agreement. I shall justify my emendation. There must be an *avamakṣepa*, in the absence

* This large deviation from the zero point of c. 505 A. D. conformed to by other *Siddhāntas* need not surprise us since this will be consistent with an earlier time by about 200 years. There is a similar shifting of the zero point in the *Vāsiṣṭha* also.

of which the *Pauliśa* new moon will have to be taken as falling at Epoch itself, so far away from others, and so wrong. We cannot take the *Romaka Ksepa* for the *Pauliśa* since in that case both new moons will fall at the same moment, very unlikely, and also the *Pauliśa*'s will be as wrong as the *Romaka*'s. Therefore the *Kṣepa* is given, and that must be 654, if we want the word *kr̥ta* to be kept. TS and NP also have to emend '*kr̥ta*' to mean 6. TS make it *r̥ta*. (NP's *ṣaṭ* is very unlikely, and unnecessary) Their emendation means "63 days are the *avamakṣepa*". What they mean is that the lunar days are to be divided by 63 days to get the *avamas*. But where is the *kṣepa* ? They neglect the word '*kṣepaḥ*'. We can understand the lunar days to be divided. But these have not become days yet, and there is no meaning in saying divide by 63 days. If "days" mean lunar days here, then it should be 64. Further, the instrumental case is required to instruct division, not the nominative. My emendation sets everything right.

This detailed discussion, though lengthy, has been required to fix the Epoch and the Sun and Moon at Epoch precisely removing any doubt. This is necessary for the determination of the Epoch constants of the star-planets of the *Vāsiṣṭha-Pauliśa*, and to compare them with the constants of the later *Siddhāntas*, and modern astronomy, which will be done in another paper.