Indian Journal of History of Science, **33**(3)1998

ON THE ORIGIN OF 'KALIYUGĀDI' SYNODIC SUPER-CONJUNCTION

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(*Received 24 June 1996; after revision 14 January 1998*)

The synodic super-conjunction that marked the beginning of Kaliyuga has been shown to be a consequence of the use of synodic periods in siddhāntic computations. As per the analysis the siddhāntic synodic period is closer to the true value in the case of planets for which the synodic period is relatively lesser, or the accuracy of the siddhantic synodic periods increase in the order of increase of the integral numbers of synodic revolutions in a Mahāyuga. This has been shown to be true for the Ārdharātrika system of Āryabhaṭa.

Author also attempts an explanation for the use of extr-long sidereal year and the 'yugādi' synodic super-conjunction in the siddhāntic astronomy. In view of the exclusive reliance on the synodic periods, the zero point in siddhāntic astronomy was the computed mean Sun corresponding to the expiry of the Kali year, rather than any fixed point or star on the ecliptic. The fact that no 'bija' was ever applied to Sun substantiates this point.

Key Words : Kaliyugādi, Siddhāntic astronomy, Synodic super-conjunction.

INTRODUCTION

According to the Ārdharātrika system of Āryabhaṭa, a synodic super-conjunction of the planetary mean longitudes at the siddhāntic 'Meṣādi' marked the beginning of Kaliyuga on the midnight of 17/18 February 3102 B.C. for the meridian of Ujjain. Scholars in general consider the aforesaid speculation as evolving out of a back calculation wrong in it's data and using the modern astronomical equations for the planetary mean elements it can be proved that no such super-conjunction did really occur at the above epoch.[1] But in the light of this evidence another line of inquiry opens up as regards the kind of 'errors' that led the early siddhāntic astronomers to the discovery of a solely computational mean conjunction of the planets. How can the errors in tbe mean elements of all planets be such that the mean longitudes converge to zero on computing back for 3600 years, with longitudes converge to zero on computing back for 3600 years, with reference to the epochal positions of kali 3600 or the vernal equinox of A.D. 499 ? In contradiction to the scientific spirit evident in the works of Aryabhata, certain

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scholars[2] have credited him with the incorporation of the speculative *yuga* concept into mathematical astronomy. To quote, Roger Billard :

"Not only did Āryabhaṭa construct *yuga* upon such beautiful reduction of observations, but I must add that almost certainly the great astronomer is responsible for the very construction of the *yuga* speculation into mathematical astronomy".

This observation is quite untenable as the values of mean sidereal day ($23^h\ 56^m\ 4^s$ 1), Pi (3.14159) etc. and the theory of earth's rotation available in *Āryabhaṭīya*[3] provide ample testimony for his pledged affiliation to scientific approach and mathematical precision and as such he would not have resorted to any arbitrary modification of the observational values of planetary elements for incorporating the *yuga* concept into the computational frame of astronomy. In fact, no evidence is forthcoming from his treatise to allege a fascination for *Purāṇic* ideas over the scientific approach.

Against the background of the above discussion, by borrowing the words of Prof. Whitney[4] it can be stated that the scientific habit of mind perceivable in Āryabhaṭa would not have permitted the admixture of the astronomical science with the absurd imagination drawn from Purāṇic literature. It is therefore likely that the epoch of *Kaliyugādi* and the synodic super-conjunction may have some mathematical rationale which remains hiterto unknown to the modern world. The present paper is an attempt to throw some light on the related intricacy of *siddhāntic* astronomy.

Siddhāntic Methodology

As observed by Rev. E. Burgess[5] in his translation of *Sūryasiddhānta*, the *siddhāntic* practice of applying 'bija' involved only the correction to the elongation of the planets relative to the sun, leaving the Sun's errors untouched. It is apparent therefore that the mean Sun corresponding to the expiry of the respective Kali-year was the zero point of *siddhāntic* astronmy and as such the other mean longitudes could be computed by the use of their synodic periods. Dr. Arka Somayaji[6] has expressed a similar view that the sidereal periods which require observations of longer periods like 30 years in the case of saturn, might have been derived from the synodic periods by use of the relation :

$$\frac{1}{S} = \frac{1}{T} \infty \frac{1}{Y}^{*}$$

Further, *Mahāyuga* being the interval between two synodic super-conjunctions, corresponding to the intergral numbers of revolutions visible in the *Siddhāntas*, there must be the integral numbers of synodic revolutions also. Based on *Sūryasiddhānta*[7] it can be inferred that the following relation was known to the *siddhāntic* astronomers.

* S = Synodic period, T = Sidereal period & Y = Length of the year.

$$\frac{Y}{S} = 1 - \frac{N}{43,20,000} \text{ ---------(1)}$$

where N is the integral number of sidereal revolutions in a *Mahāyuga* of 43,20,000 years.

Alternatively,

$$N = \left(1 \pm \frac{Y}{S}\right) \times 43,20,000 \text{ ------(2)}$$

for the (-) superior and inferior (+) planets respectively.

Explanation for the Synodic Super-Conjunction

Let 'D' be the number of days in which there are 'n' synodic revolutions. The synodic 'S' can be then expressed as

$$S = \frac{D}{n} \text{ ---------(3)}$$

The maximum possible elongation = 180° = 1/2 synodic revolution.

When 'n'→'n + 1/2', equation (3) can be re-written as

$$S' = \frac{D}{\left(n + \frac{1}{2}\right)}$$

Now, $$S - S' = \frac{D}{n} - \frac{D}{\left(n+\frac{1}{2}\right)} = \frac{\frac{D}{2}}{n^2 + \frac{n}{2}} \text{ ---------(4)}$$

Equation (4) gives the variation in the synodic period on accounting an elongation of 180° in computation over 'D' days. It is apparent that (S - Ś) tends to zero when 'n^2' becomes large as compared to 'D/2' i.e. the elongations between the Sun and the Planets becomes zero while computing betwen two distant epochs using the synodic periods, and as such computationally the synodic super-conjunction was a reality for the *siddhāntic* astronomers.

Analysis

(a) Equation (4) suggests that the *siddhāntic* synodic period will be closer to its modern true value in the case of planets for which 'n' is a maximum i.e. the *siddhāntic* synodic periods will be more accurate in the order Mars, Venus, Jupiter, Saturn, Mercury and the Moon in view of the increasing order of the integral number of synodic revolutions in a *Mahāyuga*. Alternatively, accuracy of the *siddhāntic* synodic periods increase in the decreasing order of the synodic periods i.e. from Mars to Moon as mentioned earlier. Table - I of the appendix is illustrative of this fact.

(b) At the beginning of *Kaliyuga*, all planets were within a range of ± 30° approx. from the Sun. Elongation of the different planets and (S - Ś) computed for 3600 years are given below.[8]

Col. 1 Planet	Col.2 Planet-Sun	Col. 3 S-S' for 180° Elongation	Col. 4 S-S' for the actual Elongation in column. 2	
Moon	03° 58'	3.3159×10^{-4} (days)	7.3×10^{-6} (days)	$= 0^m 0^s$ 63
Mars	-11° 37'	0.23123	-0.014923	$= -21^m 29^s$
Mercury	-33° 16'	5.1×10^{-3}	-9.43×10^{-4}	$= -1^m 21^s$
Jupiter	17° 00'	0.0605	5.71×10^{-3}	$= 8^m 13^s$
Venus	33° 05'	0.1296	0.02382	$= 34^m 18^s$
Saturn	-19° 16'	0.0543	-5.817×10^{-3}	$= -8^m 22^s$

(S - S') of column 4 is in close agreement with the difference of modern and *siddhāntic* synodic periods given in column 5 of Table I provided in the appendix. This concordance substantiates the computational origin of synodic super-conjunction.

Taking the specific case of Jupiter as an example, (S - Ś) for 1/2 synodic revolution increment in 3600 years = 0.0605 days = 87 minutes i.e. if the synodic period of the siddhāntas differed from its true value by 87 minutes, the longitude of Jupiter varies by 180° while computing across 3600 years. At the beginning of *Kaliyuga* the elongation of Jupiter was only 17° and this small difference automatically cancel out for a difference of 8^{mm} 13^{sec} in the synodic period. Similar is the case with all planetary mean longitudes at the beginning of *Kaliyuga*.

(c) Alternatively, the above computational effect can be illustrated using the annual synodic variation Y/S, which accordong to the siddhāntic elements of Table. I and modern astronomy are as follows :

Planet	Siddhāntic Y/S	Modern Y/S	Difference
Jupiter	329° 38' 54"	329° 39' 1".47	- 7". 47
Saturn	347° 47' 10" .8	347° 46' 43".1	+ 27" .7

The difference in *siddhāntic* Y/S leads to a variation of -7° .47 and 27° .7 for Jupiter and saturn respectively in 3600 years. Because of this reason Jupiter and Saturn had the above deviations at the beginning of *Kaliyuga* from the *siddhāntic* zero point viz, the vernal equinox of A.D. 499 for the *Ārdharātrika* system of Āryabhaṭa.

YUGA SYSTEM - A MATHEMATICAL MODEL

Correlation between the inaccuracy of the *siddhāntic* synodic periods and the elongation of the planets at the beginning of Kaliyuga suggest that the siddhāntic mean planetary elements all are entirely theoretical in origin. Even though such an inference is contrary to what we may expect, it can be satisfactorily explained as follows :

The yuga system itself probably reflect the computation using synodic period. The definition of the year of Brahma as 360 divine 'days' or 360 solar years is obviously a reflection of the unit *sauradina* as can be seen in *pañcasiddhāntika* Chapter XVIII. The divine to solar years conversion with multiplication by 360 appears to have evolved out of the following siddhāntic method of derivation of the integral number of revolutions.

$$\left(\frac{Y}{S}\right) = \text{Annual Synodic Variation}$$

$$360 \times \left(\frac{Y}{S}\right) = \left(\frac{Y^{\circ}}{S}\right) = \text{Synodic revolutions of 360 years} = n_{360}$$

$$\text{i.e. } \left(\frac{Y'}{S}\right) = n_{21600} \;\&\; \left(\frac{Y}{S}\right)'' = n_{1296000}$$

Obviously the integral number of sidereal revolutions N could be obtained simply as :

$N = 1296000 - n_{1296000}$ (just by the use of the annual synodic variation).

i.e. $N = 1296000 - \left(\frac{Y}{S}\right)''$.

Thus the synodic variation or elongation of planets corresponding to the solar arc of 1° (1 *Sauradina*) expressed in seconds of arc represented the integral numbers of revolutions for 3600 years.

Accuracy of the planetary computations depend upon the precision with which the epochal positions have been observationally ascertained and on the correctness of the planetary motion. As we saw earlier, the methodology of *siddhāntic* astronomers demanded the most precisely determined synodic periods for arriving at the correct planetary elongations with reference to the mean Sun of the respective expiry of Kali-year. In this context, the theoretical values based on the *Yugādi* synodic super-conjuncton were probably more reliable than the observationally determined synodic periods i.e. the interval between two successive helical risings or settings. For example, Āryabhaṭa himself accepted the theoretical values as they were providing the best fit with the observations as compared to the observationally deduceable crude values of such distant past. It is quite likely that the ancient astronomers had no sufficient provisions for determining the interval between two successive helical risings with accuracy upto minutes.

But it must be noted that the synodic period of Moon was exactly known to the ancient Indian astronomers because of the reasons outlined in section 3, and as such the

Yuga rightly began on a new-Moon day. The Sun was behind the reference point *viz.*, the equinox of A.D. 499, and this necesstated an extra-long sidereal year of 365.25875 days. As such in *siddhāntic* astronomy, the Sun has been already brought to an accordance with the initial point by the definition of the year length and hence no correction was ever applied to it since the close of the 5th Century AD.

The above factors also explain the need felt by the ancient astronomers for successive revision of the *karaṇa* works and as noted by Prof. Whitney (4) the non-availability of long time observational records in siddhāntic astronomy. Further the large variation of the sidereal period of Saturn from the actual value suggests that the sidereal periods have been exclusively dependent upon the theoretical values of 'S' and 'Y' given in Table I.

EXPLANATION FOR 'KALPĀDI' COMPUTATION BY BRAHMAGUPTA

The inference drawn earlier that the Āryabhaṭa's mean motions are theoretical in origin is likely to be contested by the scholars. But supporting evidence for this imference is available in the later work of Brahmagupta. As observed by Roger Billard - had the Yuga system propounded by Āryabhaṭa been an arithmetical articulation of the observational values of mean motions[9] - Brahmagupta* could also have done the same i.e. he could have expressed the observational values in terms of the Mahāyuga revolutions itself, rather than resorting to *Kalpādi* computation. As can be seen from equation (4), *Kalpādi* computation was an attempt to derive more precise theoretical values by use of greater values of the integral number of synodic revolutions (n).

According to Brahmagupta, the number of years elapsed since the *Kalpādi* upto the epoch of *Brāhmasphuṭa - siddhānta* (Kali 3729) is 1972947729[4]. Taking, Jupiter as an example, (S - Ś) corresponding to a variation of 180° in the elongation can be computed as 1.1×10^{-7} days i.e. 0.0095 seconds. Therefore by introducing little variation in the theoretical values of mean motions, the computational results could be made to fit with the observational values. Even though the synodic period of Jupter is almost the same as that of *Ārdharātrika* system, in the case of *Brāhmasphuṭa-siddhānta*, the mean longitude of Jupiter has a difference of 32' as compared to the placement at 0° according to Āryabhaṭa's beginning of Kaliyuga. Similar is the case with Mars, Venus, Mercury and Saturn. It must be noted that the Sun and Moon were still at the zero point. Obviously, Brahmagupta discarded the *Yugādi* super-conjunction for obtaining better agreement with the observations at his epoch of Kali 3729, by the use of theoretical values. Had the basis of his siddhānta been the observational mean

* Brahmagupta's criticism that Āryabhaṭa is ignorant of mean motions in view of the departure of the *Yuga* system from *Smṛtis* also point towards the theoretical origin of mean motions. (S.B. Dikshit has quoted in ref. 4).

motions there was no need for defining the *Kalpādi*—it was sufficient to define the epoch of kali 3729 with the accurately determined planetary positions. This is true about Āryabhaṭa also who had no sufficient reasons for defining *Yugādi* with the zero mean longitudes, instead of defining *kali* 3600 as the fundamental epoch along with the observational values of mean motions.

Compulsion for the Extra-Long Sidereal Year :

Further the methodology described above led to the serious discrepancy in the length of the year. At the beginning of *Kaliyuga* the tropical longitude of Sun was 301° 40' while the vernal equinox of *Yugādi* was 58° 20' east of the tropical mean Sun.[10] The zero point of *Ārdharātrika* system of Āryabhaṭa was the equinox of kali 3600, placed at 50° 22' west of the *Yugādi* Vernal equinox.[11] True sidereal year would have accounted for 50° 22' by precession over 3600 years, but *Yugādi* mean Sun demanded an adjustment of 58° 20' for coincidence with the equinox. The surplus 58° 20' - 50° 22' = 7° 58' was met by adopting an extra-long sidereal year of 365.25875 days. By the use of an observationally determined sidereal period of Sun or by adopting either of the values of Ptolemy or Romaka which were available in his times, it was imposible to begin the *Yuga* from the new-Moon of 17/18 February 3102 BC. The compulsion for the use of an abnormal sidereal year obviously arose out of the total reliance of the siddhāntic astronomers on the theoretical synodic periods emerging from the concept of *Yugādi* synodic super-conjunction.

Conclusions

The mean synodic super-conjunction at the beginning of *Kaliyuga* was a consequence of the computational method employed by the early *siddhāntic* astronomers. Dependence on synodic revolutions brought into effect the equation, $(S - \acute{S}) = D/2\ (n^2 + n/2)$, and hence the astronomical system was compelled to adapt itself to the concepts of 'Yugādi' and synodic super-conjunction. This in turn necessitated an extra-long sidereal year for bringing the Yugādi mean Sun to the epochal zero point, viz. the vernal equinox of *Kali* 3600 (A.D. 499). The *siddhāntic* synodic and sidereal periods of Āryabhaṭa, Brahmagupta etc. were solely theoretical rather than observational and they served only the limited purpose of 'computation in the vicinity of an epoch'. All the *Karaṇa* works therefore required periodic revisions by the use of the observationally determined accurate epochal planetary positions. It is apparent from the analysis that in the absence of the compulsion due to reliance on the synodic periods and the limitation of determining more precise observational values Āryabhaṭa or Brahmagupta would not have allowed the entry of Purāṇic speculations into mathematical astronomy. In the light of this explanation which point towards a mathematical rationale, the age old criticism of siddhāntic astronomy by Prof. Whitney for the inclusion of the *Yuga* system into astronomy stands untenable. Further, it point towards the indigenous origin and it is quite likely that the Purāṇic chronology is a by product of the astronomical development rather than the use of Purāṇic chronology in astronomy as alleged by certain critics.

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