

3 Astronomical elements and planetary models

Is it not wonderful in any case, that the most modern and accurate parameters help us to discover and appreciate better than ever before the very accurate Indian observations made nearly 1500 years ago ?

- R.Mercier (p 102)

In any event, there is probably no better place to study comparative science than in Oriental Astronomy. Nevertheless, the field poses formidable problems, foremost being the variety of languages involved. It does no good simply to know Chinese and no other language. We need Chinese scholars who know Sanskrit, Arabic scholars who read Chinese, Indian scholars who command Greek, and so on.

- O.Gingerich (p.274)

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Among the historians of Indian astronomy, John Bentley seems to be first to stress, nearly two hundred years ago, that *yuga* and *kalpa*, which form the basic time-divisions used for traditional astronomical computations in India, are not historical but astronomically interpolated. Bentley says that a division of time simply into the four *yugas*, viz. *Kṛta*, *Tretā*, *Dwāpara* and *Kali*, was introduced in 204 B.C. "It appears," as Bentley surmises, "that at, or about this period (204 B.C.), improvements were made in astronomy; new and more accurate tables of the planetary motions and positions were found, and equations introduced. Beside these improvements, the Hindu history was divided into periods, for chronological purposes. ...The period immediately preceding the inventor was called the first, or *Kali yuga*; the second or next, was called the *Dwāpara Yuga*; the third was called the *Tretā Yuga*; and the fourth, or furthest back from the author, was called *Kṛta Yuga* and with which the creation began. The end of the first period, called *Kali* was fixed by a conjunction of the Sun, Moon and Jupiter, in the beginning of Cancer, on the 26th June 299 B.C. This was called the *Satya Yuga*, or true conjunction, and is the radical point from which the calculation proceeds" (Bentley 1823, p.61-62).

Bentley then asserts that the *kalpa* division of time was introduced in A.D. 538, and adduces a fantastic reason for the innovation. About the epoch commencing with A.D.538, he says: "This epoch is one of greatest importance, ... as it was now that means were adopted by the Brahmins for completely doing away their ancient history and introducing the periods now in use; by which they threw back creation to the immense distance of 1,97,29,47,101 years before Christian era, with a view, no doubt, to arrogate to themselves that they were the most ancient people on the face of the earth.

"The various means or contrivances that were adopted for this purpose will now be explained:- In the first place, they made choice of a period of 4,32,00,00,000 years, which they called the *Kalpa*. This period they divided and subdivided into lesser periods, which, the better to answer their purpose, they called by the same names of the periods of the two former divisions of the Hindu history were designated, (viz. *Kṛta*, *Tretā*, *Dwāpara* and *Kali*), in order that they might be conceived to be the same". Bentley continues: "Matters thus far settled, the next step was to ascertain by computation, a point of time from which the calculation of the length of the year and the mean motions of the

planets should proceed in order to determine the number of revolutions in each *Kalpa*, preparatory to their application to astronomical purposes. The only point of time they could find to answer this purpose was the 18th February, in the year 1612 of the Julian period, and this point they made the commencement of the *Kali Yuga*, of the 28th *Mahā Yuga*, of the seventh *Manwantara*" (Bentley 1823, p.69-71).

Bentley proceeds to state: "The point of time thus fixed on was found by computation made backwards, which showed that the planets were approximating to a mean conjunction in the beginning of the sidereal sphere commencing with the Lunar asterism *Aśvinī*, on which account it was made choice as the point to proceed from, for, had the approximation of the planets been in any other part of the heavens, it would not have answered their purpose; because their object was to assume the sun, moon and all the planets to be then in a line of mean conjunction in the beginning of *Aśvinī*, or the sidereal sphere, in order that from that assumption, as if it had been an actual observation, they might determine the length of the year and mean motions of planets, sufficiently near the truth to answer their purpose"(Bentley 1823, p.71-72).

Bentley's prejudices and insinuations apart, and also his way of putting the cart before the horse by proposing that the length of the *kalpas* and *yugas* was decided upon first and then only a particular date in the first year of *kalpa* or *yuga* was sought for answering certain specifications, instead of the other way, his line of argument would be clear from the above.

Roger Billard(1971, p.222), in his recent work, *L'astronomie indienne*, and also elsewhere, ascribes the introduction of the current concept of the four yugas to *Āryabhaṭa* (born A.D. 476). Billard says: "Not only did *Āryabhaṭa* construct *yuga* upon such beautiful reductions of observations, but I must add that almost certainly the great astronomer is also responsible for the very introduction of the *yuga* speculation into mathematical astronomy.

Prof. T.S. Kuppanna Sastry observes on this point: "All scholars agree that the mean sun and moon are at the zero point of *Aśvinī* at the above-mentioned *Kali* epoch. Excepting school No(3), the others are also agreed that the mean planets too are at that point at the Epoch and that the moon's apogee is 90° and the node 180° from that. What are we to understand from this? Are we to think that at such an ancient date as 17/18 February, 3102 B.C. the Hindu astronomers gave this result as got from their observation? Or, was this point of time fixed by some later astronomers as a convenient epoch for starting their calculations? The former alternative cannot be accepted, because the mean sun, moon and planets were not the same but differed widely from one another, nor were they at zero *Aśvinī* as calculated by modern astronomy for that epoch. Scholars like Bentley first conceived this idea of verification by calculation. Bentley showed that starting from the epoch and working by each *siddhanta*, the error gradually became less and less, until at the

time of the later *siddhāntas*, the error became a minimum, as must be expected. Thus, he proved that the second alternative was the correct one, and that the Kali era starting from this epoch was an extrapolated era founded by astronomical *siddhāntins*" (Sastry 1974, p.34).

With regard to original Sanskrit texts, normally one cannot expect them to go into the rationale or the justification or otherwise of the traditionally accepted concepts of *kalpa* and *yuga*. It has however been possible to identify a few texts which categorically state about these concepts being of an interpolated nature. For instance, the Kerala astronomer Putumana Somayāji, mentioning the different yuga divisions adopted by different schools, asserts that these yuga-measures have been conceived only as a means of computation to arrive at correct results. Thus, he states:

*Kalpādīnām pramāṇam tu bahudhā kalpyate budhaiḥ/
upeyasyaiva niyamo nopayasyeti yat tataḥ//
(Karaṇa Paddhati, 5.15)*

He then proceeds to recount the different schools;

*Kalpe yugāni sahasram uśanti kecit
tatraikasaptati yugāni pṛthān manūnām /
adyantayoś ca vivare ca tathaiiva teshām
syuḥ sandhayo yugadaśamsacatushkatulyāḥ //16//
manavo'thā caturdaśaiiva kalpe
'pṛthu'tulyāni yugāni caiva teshām /
triyugāni gatani sṛṣhtitah prak
parataḥ syuḥ pralayāt tathāhur anye //17//
yugasya daśamo bhāgo 'bho-ga-pri-ya'hataḥ kramāt /
kṛtadinām pramaṇam tu syāt pakshayor anayoḥ dvayoḥ //18//
kalpe'smiṅ saptamasyāya vaivasvatamanor yuge /
ashtavimśe Kalīḥ sarvair vartamāna iha smṛtāḥ //19//*

About Āryabhata's concept of the *yuga*, which is different from the above, our author says:

*kr̥ta-tretā-dvāparākhyāḥ kaliś caite yugāṅghrayāḥ /
yugāṅghrayas tu kaple 'smin 'dhigaditya'mitā gataḥ //
(Karaṇa Paddhati 1.7)*

"The measures of *kalpa* etc. have been conceived by the (ancient) authorities differently, for, it is only the result that counts, not the means (Karaṇa Paddhati, 5.15).

"Some (like the *Sūryasiddhānta*, Bhāskara II etc.) take the number of yugas in a *kalpa* to be 1000. Each of the 14 manu periods would have 71 yugas; between the beginning and end of each of the 14 yugas, there are (in all, fifteen) contact periods, each equal to four-tenths of a yuga." (16)

"Still others say that the number of *manu* periods in a kalpa is only 14, each having 71 *yugas*, but that 3 *yugas* have passed by before Creation and 3 *yugas* will occur only after Dissolution".(17)

"According to the above two views, the measure of the *Kṛta*, (*Tretā*, *Dvāpara* and *Kali yugas*) are in the proportion of 4, 3, 2, and 1 tenth parts of the (*catur-yuga*)".(18)

"All agree that today, the current *yuga* is *Kali* in the 28th (*catur-yuga* of the 7th *manu* (viz *Vaivasvata-manu*) in the present *kalpa*." (19)

"(According to *Āryabhaṭa*), (the measures of) each of the four *yugas*, *Kṛta*, *Tretā*, *Dvāpara* and *Kali* (are equal, being) one-fourth of the (*catur-yuga*. In the current kalpa, 1839 quarter-*yugas* are gone! (*Karaṇa Paddhati*, 1.7)"¹.

Whatever be the *yuga*-concept adopted, astronomers stress that the computed result should accord with observation. Thus, another Kerala astronomer, *Parameśvara* (1380-1460) states, in his *Suryasiddhanta-tavaraṇa*, (*Shukla 1957, p.21*), under 1.66:

grahānām atra siddhānām dr̥gbhedo dr̥śyate 'dhunā /
dr̥gbhedahetuḥ ko'tra syad asmābhir iti cintyate //1//
avyavasthā tu khetānam bhukter eva hi yujyate /
śaighryam māndyam tathā kalpyam kramād eva gates tataḥ //2//
kalato gatibhedac ca siddhānta bahudhā kṛtāḥ /
Brahmad̥yair ity atāḥ siddhām bheo'tas tēshu yujyate //3//
tattatkale gatiṣād anumānena kalpitāḥ /
bhagaṇas tair nijānīje siddhānte siddham ity api //4//
dr̥śyamāno 'dhunā teshām dr̥gbhedāḥ sr̥ṣṭīkalataḥ /
urdhvakālena sanjāta iti kalpyam budhair atāḥ //5//

"There is found difference between the (longitudes of) planets as computed and as observed at present. I am discussing as to what could be the cause of the said difference in the observed positions."(1)

"Variation in the planets can be assigned only with regard to their rates of motion. Hence, increased fastness or slowness, as the case may be, shall have to be presumed in the rates of motion of the planets."(2)

"It is, therefore, only proper that a number of *siddhānta* texts have been produced by *Brahmā* and others on account of their differences (from one another) in the matter of the time (of their production) and the then rates of motion of the planets."(3)

"Hence it is also proper that the number of *yuga*-revolutions are determined through deduction from the rates of motion at specific times, for the different *siddhāntas*."(4)

"It, again, stands to reason to ascribe the differences that are now observed in the planetary positions to their having developed differences in their rates of motion during the passage of time from creation to the present time."(5)

In the verses following, this author has worked out the actual positions of the planets that would have been occupied by them at the beginning of Kali, on the basis of the current rates of their motion and has given the results as zero corrections to Kali beginning.

Another astronomer who has expressed similar views is Śaṅkara Vāriyar (1500-60), who, in his commentary *Yuktidīpikā* (Sarma 1977, p.73) on the *Tantrasaṅgraha* of Nīlakaṇṭha Somayāji, 1.35, states:

*kalyādu na niraṃśatvaṃ bhagaṇāder dyucāriṇām /
gatibhedāt tu dr̥ksiddhās tatraishām syur dhruvas tataḥ//*

"At zero Kali, the revolutions etc. of the planets cannot (be taken to) commence from their zero positions, on account of the (subsequent) change of their velocities. Therefore, zero corrections should be set for them as calculated from their currently observed positions."

In his *Karaṇapaddhati*, Putumana Somayāji not only states the necessity of revising, suitably, the *yuga*-revolutions and other constants, but sets out the methods therefor:

*grahaṇa-grahayogādyair ye grahāḥ suparīkṣhitāḥ /
dr̥ksamas tatsamaḥ kalpe kalpyā vā bhagaṇādayaḥ //5.1//
parīkṣhitasya kheṭasya tantranītasya cantaram /
liptīkr̥tyarkhagnaiḥ kalpokaṭais' ca samahatam //2//
tantranīrmanākalāsyā parīkṣhasamayasya ca /
antarālagatair abdaḥ rāśicakrakalāhataiḥ //3//
hrtvā'ptam tantranītasya grahasyālpādhikatvataḥ /
svaṇnam tat kalpabhagaṇe kuryan naiṣha vidhī raveḥ //4//*

"(The number of) planetary revolutions (taken to constitute) a *kalpa* (according to the *siddhānta* taken up for consideration) should be revised (periodically) so that eclipses and planetary conjunctions computed using those numbers would accord with observation."(1)

"(Towards effecting such revision) take the difference between the true positions of a planet as observed (in the sky) and as computed using the number of revolutions (enunciated in the *siddhānta*) and reduce the difference to minutes. Multiply this by the Sun's *kalpa* revolutions and divide by the number of years between the time of the composition of the *siddhānta* (or other text) at which time it is to be presumed that the computation accorded with observation). Reduce the quotient (which would be in full cycles) to minutes by multiplying it by 21,600, (being the number of minutes contained in a circle)".(2-3)

"The result (which is the correction in terms of revolutions) is to be added to or subtracted from the number of the (currently accepted)

kalpa revolutions (enunciated in the *siddhānta* or text) according as the true planet determined by computation is less or more (than the observed true planet). This mode of correction is not to be applied to revise the Sun's revolutions (since the basis itself of the correction is the Sun's revolutions). (4) The above discussion is a pointer also to the fact that astronomical science in India had not remained stagnant and static as is generally supposed and often alleged. It had been evolving, in a particular manner, continually in different spheres and at different levels.

NOTES

- 1 1839 quarter-*yugas* would amount to 6 *manus*, 27 full *yugas* and 3 quarter-*yugas*, the quarter-*yuga* current today being of Kali *yuga* in the 28th *manu* period, in consonance with the other schools. There is still another school followed by *Saura-Siddhānta* of the *Pañcasiddhāntikā* of Varāhamihira, followed also by the Midnight system of Āryabhaṭa and the *Khaṇḍakhādya* of Brahmagupta.

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 2 Translated into English, Univ. of Calcuta, 1934.
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I would like to point out that we must be perfectly clear that the driving motive behind the incessant Chinese observations of the sky phenomena was purely astrological in nature. What was paramount was the ability to know in advance important events bearing upon the immediate future of the ruling imperial family.

- Teboul (p.260)