THE SOLAR NUMBERS IN ANGKOR WAT

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The great Viṣṇu temple at Angkor Wat in north- central Kampuchea (Cambodia) is known to have been built according to an astronomical plan. In this note we show that the little-understood solar formula of the temple is identical to the one in the *Śatapatha Brāhmaṇa*. We propose that the Angkor Wat formula was an expression of the *Śatapatha* astronomy.

The great Viṣṇu temple of Angkor Wat was built by the Khmer Emperor Sūryavarman II, who reigned during AD 1113-1150. This temple was one of the many temples built from AD 879-1191, when the Khmer Civilization was at the height of its power. The Viṣṇu temple has been called one of humankind's most impressive and enduring architectural achievements. Fig. 1 presents a plan of the temple complex upto the moat and Fig. 2 presents a plan of its inner three galleries.

More than 20 years ago *Science* carried a comprehensive analysis by Stencel, Gifford and Moron (SGM) of the astronomy and cosmology underlying the design of this temple.[1] The authors concluded that it served as a practical observatory where the rising sun was aligned on the equinox and solstice days with the western entrance of the temple, and they identified 22 sighting lines for seasonally observing the rising of the sun and the moon (Fig. 3). Using a survey by Nafilyan[2] and converting the figures to the Cambodian cubit or *hāt* (0.435m) , SGM demonstrated that certain measurements of the temple record calendric and cosmological time cycles.

In addition, SGM showed that the west-east axis represents the periods of the *yugas*. The width of the moat is 439.78 *hāt*; the distance from the first step of the western entrance gateway to balustrade wall at the end of causeway is 867.03 *hāt*; the distance from the first step of the western entrance gateway to the first step of the central tower is 1,296.07 *hāt*; and the distance from the first step of bridge to the geographic center of the temple is 1,734.41 *hāt*. These correspond to the periods of 432,000; 864,000; 1,296000; 1,728,000 years for the *Kali, Dvāpara, Tretā*, and *Kṛta* yuga, respectively.

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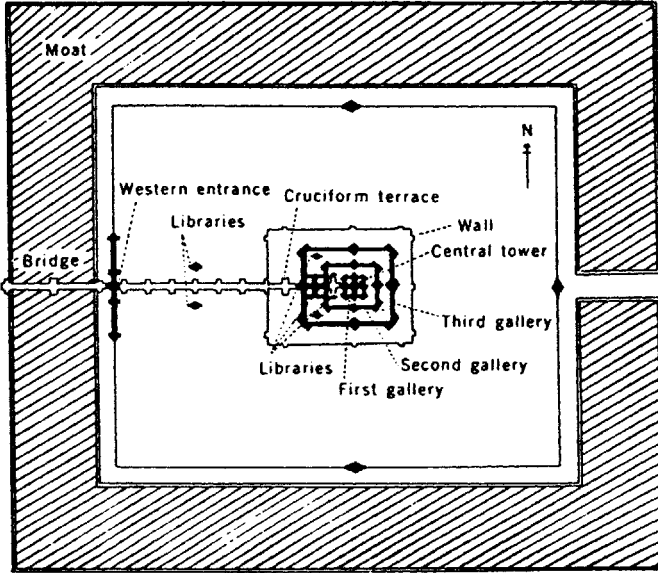
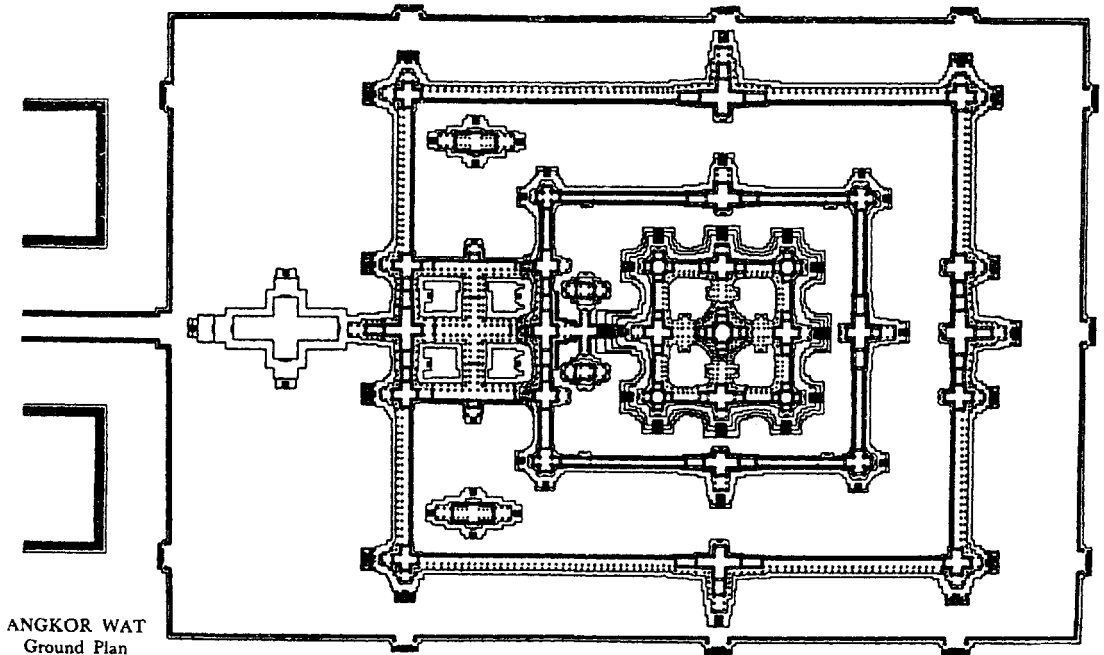Fig.1   The plan of the temple complex

ANGKOR WAT
Ground Plan

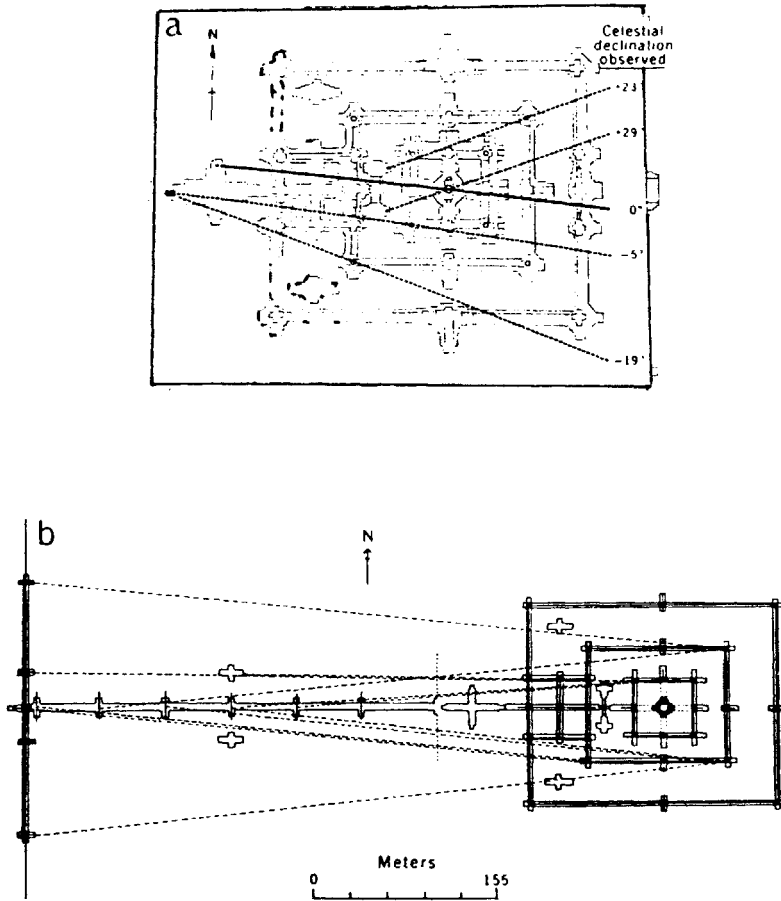Fig.2   The plan of the inner three galleries

Fig.3 The astronomical alignments for the observation of the Sun and the Moon.

SGM suggest that the very slight discrepancy in the equations might be due to human error or erosion or sinking of the structure.

In the central tower, the topmost elevation has external axial dimensions of 189.00 *hāt* east-west, and 176.37 *hāt* north-south, with the sum of 365.37. In the words of SGM, this is "perhaps the most outstanding number" in the complex, "almost the exact length of the solar year." But SGM were not able to explain the inequality of the two halves; which is the problem that we take up in this paper. We will show that these numbers are old *Śatapatha Brāhmaṇa* numbers for the asymmetric motion of the Sun.

THE HISTORICAL BACKGROUND OF ANGKOR WAT

The kings of the Khmer empire ruled over a vast domain that reached from what is now southern Vietnam to Yunan, China and from Vietnam westward to the Bay of Bengal. The structures one sees at Angkor today, more than 100 temples in all, are the surviving religious remains of a grand social and administrative metropolis whose other buildings- palaces, public buildings, and houses - were all built of wood and are long since decayed and gone. As in most parts of India where wood was plentiful, only the gods had the right to live in houses of stone or brick; the sovereigns and the common folk lived in pavilions and house of wood.

Over the half-millennia of Khmer rule, the city of Angkor became a great pilgrimage destination because of the notion of Devarāja, that has been explained by Lokesh Chandra as a coronation icon. Jayavarman II (802-850) was the first to use this royal icon. According to Lokesh Chandra,

> Devarāja means 'king of the Gods' and not 'God-King'. He is Indra and refers to the highly efficacious *aindra* mahābhiṣeka of the Ṛgvedic rājasūya tradition as elaborated in the *Aitareyabrāhamaṇa*. It was not a simple but a great coronation, a *mahābhiṣeka*. It was of extraordinary significance that Jayavarman II performed a Ṛgvedic rite, which lent him charismatic authority.[3]

The increasingly larger temples built by the Khmer kings continued to function as the locus of the devotion to the Devarāja, and were at the same time earthly and symbolic representations of mythical Mt. Meru, the cosmological home of the Hindu gods and the axis of the world-system. The symbol of the king's divine authority was the sign (*liṅga*) of Śiva within the temple's inner sanctuary, which represented both the axes of physical and the psychological worlds. The worship of Śiva and Viṣṇu separately , and together as Harihara, had been popular for considerable time in southeast Asia; Jayavarman's chief innovation was to use ancient Vedic *mahābhiseka* to define the symbol of government. To quote Lokesh Chandra further,

> "The icon used by Jayavarman II for his *aindra mahābhiṣeka*, his Devarāja = Indra (icon), became the symbol of the Cambodian state. as the sacred and secular sovereignty denoted by Prajāpatiśvara / Brahmā. as the continuity of the vital flow of the universal (*jagat*) into the stability of the terrestrial kingdom (*rāja = rājya*). As the founder of the new Kambuja state, he contributed a national palladium under its Cambodian appellation *kamraten jagat ta rāja / rājya*. Whenever the capital was transferred by his successors, it was taken to the new *nagara*, for it had to be constantly in the capital."[4]

Angkor Wat is the supreme masterpice of Khmer art. The descriptions of the temple fall far short of communicating the great size, the perfect proportions, and the astoundingly beautiful sculpture that everywhere presents itself to the viewer.

As an aside, it should be mentioned that some European scholars tended to date Angkor Wat as being the 14th century. The principal reason was that some decorative motifs at Angkor Wat show a striking resemblance to certain motifs of the Italian Renaissance. This argument, which is similar to the one used in dating Indian mathematical texts vis-a-vis Greek texts, has been proven to be wrong. In the words of Coedes,[5] "If there is some connection between the twelfth-century art of the Khmers, the direct heirs to the previous centuries, and the art of the Renaissance, it must have been due to a reverse process, that is to the importation of oriental objects into Europe."

ASTRONOMY OF ALTARS AND TEMPLES

To understand the astronomical aspects of Angkor Wat it is necessary to begin with the Indian traditions of altar and temple design on which it is based. And since the Angkor Wat ritual hearkened to the Vedic past, it stands to reason that its astronomy was also connected to the Vedic astronomical tradition.

In a series of publications I have shown that the Vedic altars had an astronomical basis.[6] In the basic scheme, the circle represented the earth and the square represented the heavens or the deity. But the altar or the temple, as a representation of the dynamism of the universe, required a breaking of the symmetry of the square. As seen clearly in the *agnicayana* and other altar constructions, this was done in a variety of ways. Although the main altar might be square or its derivative, the overall sacred area was taken to be a departure from this shape. In particular, the temples to the goddess were drawn on a rectangular plan. In the introduction to the *Śilpa Prakāśa*, a 9th-12th century Orissan temple architecture text, Alice Boner writes,[7] "[the Devī temples] represent the creative expanding forces, and therefore could not be logically be represented by a square, which is an eminently static form. While the imminent supreme principle is represented by the number ONE, the first stir of creation initiates duality, which is the number TWO, and is the producer of THREE and FOUR and all subsequent numbers upto the infinite." The dynamism is expressed by a doubling of the square to a rectangle or the ratio 1:2, where the *garbhagrha* is now built in the geometrical centre. For a three-dimensional structure, the basic symmetry-breaking ratio is 1:2:4, which can be continued further to another doubling.[8]

The constructions of the Harappan period (2600-1900 BC) appear to be according to the same principles. The dynamic ratio of 1:2:4 is the most commonly encountered size of rooms of houses, in the overall plan of houses and the construction of large public buildings. This ratio is also reflected in the overall plan of the large walled sector at Mohenjo-Daro called the citadel mound. It is even the most commonly encountered brick size.[9]

There is evidence of temple structures in the Harappan period in addition to iconography that recalls the goddess. Structures dating to 2000 BC, built in the design

of *yantras*, have been unearthed in northern Afghanistan.[10] There is ample evidence for a continuity in the religious and artistic tradition of India from the Harappan times, if not earlier. These ideas and the astronomical basis continued in the architecture of the temples of the classical age. Kramrisch has argued that the number 25,920, the number of years in the precessional period of the earth, is also reflected in the plan of the temple.[11]

According to the art-historian Alice Boner,[12]

> [T]he temple must, in its space-directions, be established in relation to the motion of the heavenly bodies. But in as much as it incorporates in a single synthesis the unequal courses of the sun, the moon and the planets, it also symbolizes all recurrent time sequences: the day, the month, the year and the wider cycles marked by recurrence of a complete cycle of eclipses, when the sun and the moon are readjusted in their original positions, a new cycle of creation begins.

It is clear then that the Hindu temple is a conception of the astronomical frame of the universe. In this conception it serves the same purpose as the Vedic altar, which served to express the motions of the sun and the moon. The progressive complexity of the classical temple was inevitable given an attempt to bring in the cycles of the planets and other ideas of the *yugas* into the scheme.

A text like the *Śilpa Prakāśa* would be expected to express the principles of temple construction of the times that led to the Angkor Wat temple. Given the prominence to the *yuga* periods in Angkor Wat and a variety of other evidence it is clear that there is a continuity between the Vedic and Purānic astronomy and cosmology and the design of Angkor Wat.

SOLAR AND LUNAR MEASUREMENTS

Some of the solar and lunar numbers that show up in the design of the Angkor Wat temple are the number of *nakṣatras*, the number of months in the year, the days in the lunar month, the days of the solar month, and so so.[13] Lunar observations appear to have been made from the causeway. SGM list 22 alignments in their paper, these could have been used to track not just the solar and lunar motions but also planetary motions.

The division of the year into the two halves: 189 and 176.37 has puzzled SGM. But precisely the same division is described in the *Śatapatha Brāhmaṇa*. In layer 5 of the altar described in the *Śatapatha*, a division of the year into the two halves in the proportion 15:14 is given (Fig.4).[14] This proportion corresponds to the numbers 189 and 176.4 which are just the numbers used at Angkor Wat.

Fig. 5 explains the physics behind the asymmetry in the Sun's orbit. As one can see, the period from the autumnal equinox to the vernal equinox is smaller than the opposite circuit. The interval between successive perihelia, the anomalistic year, is 365.25964

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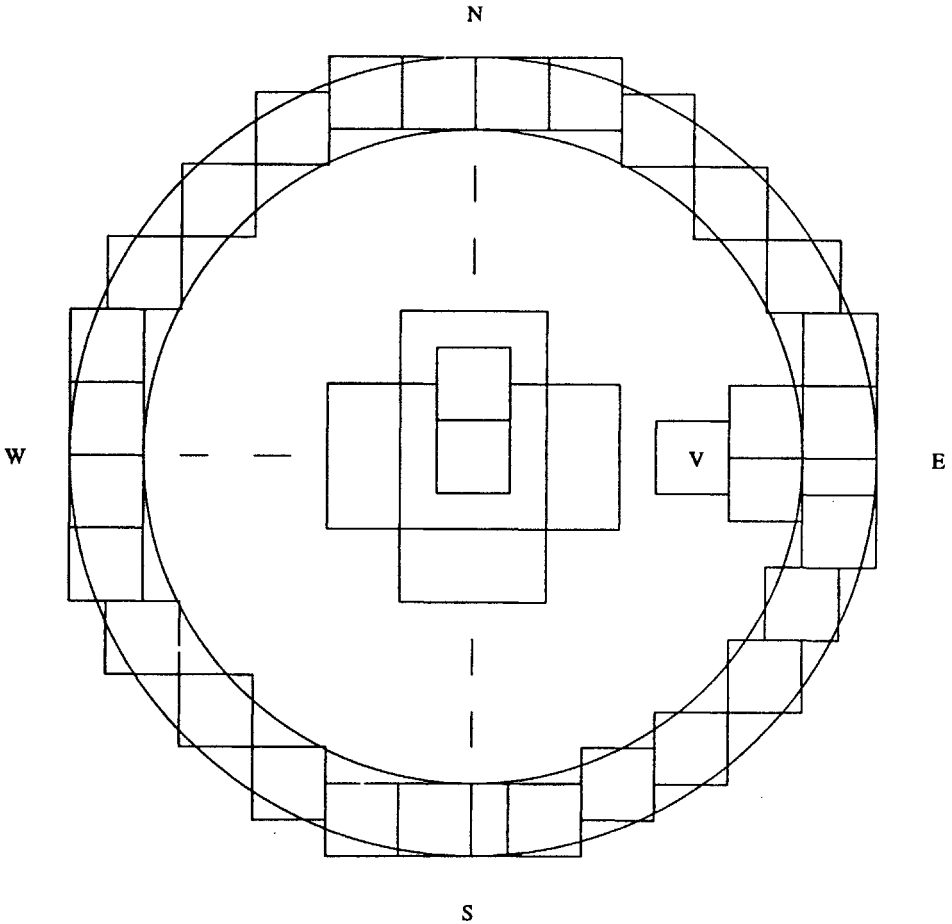
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Fig. 4   The Śatapatha altar describing the circuit of the Sun

days which is 0,01845 days longer than the tropical year on which our calendar is based. In 1000 calendar year, the date of the perihelion advances about 18 days. Considering Fig.5 again, the perihelion was roughly on December 18 during the time of the construction of Angkor Wat; and it was on October 27 during early 2nd millennium BC, the most likely period of the composition of the *Śatapatha Brāhmaṇa.* In all these cases the perihelion occurs during the autumn / winter period, and so by Kepler's 2nd law we know that the speed of the sun in its orbit around the earth is greater during the months autumn and winter than in spring and summer.
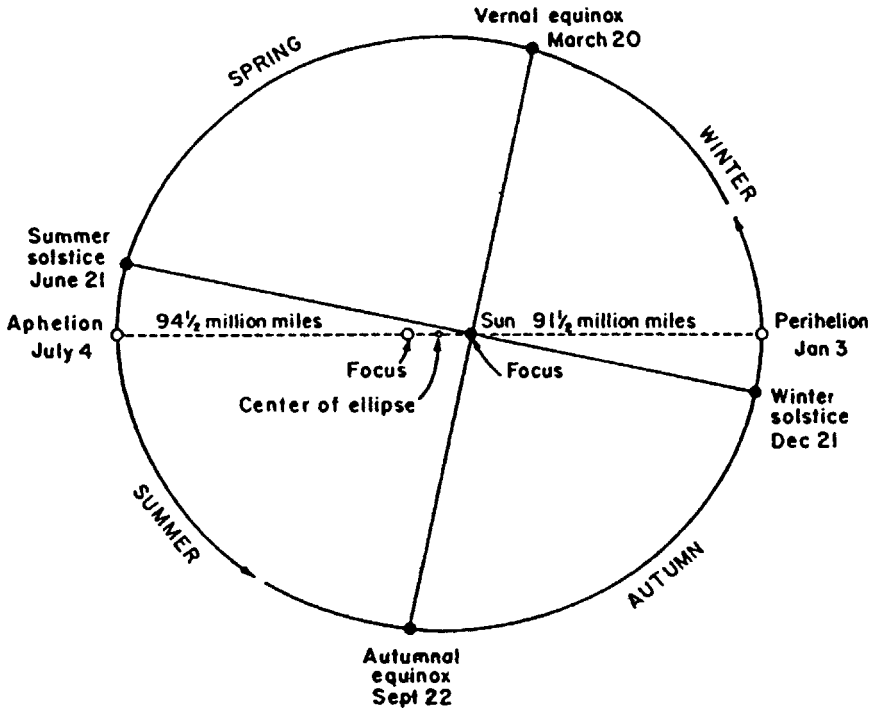
Fig. 5   The asymmetric circuit of the Sun

During the time of the *Śatapatha Brāhmaṇa*, the apogee was about midway through the spring season, which was then somewhat more than 94 days. The extra brick in the spring quadrant (Fig. 4) may symbolically reflect the discovery that this quarter had more days in it, a discovery made at a time when a satisfactory formula had not yet been developed for the progress of the sun on the ecliptic.

It is possible that the period from the spring equinox to the fall equinox was taken to be about 189 days by doubling the period of the spring season; 176 days became the period of the reverse circuit.

Why not assume that there was no more to these numbers than a division into the proportions 15:14 derived from some numerological considerations? First, we have the evidence from the *Śatapatha Brāhmaṇa* that expressly informs us that the count of days from the winter to the summer solstice was different, and shorter, than the count in the reverse order. Second , the altar design is explicitly about the sun's circuit around the earth and so the proportion of 15:14 must be converted into the appropriate count with

respect to the length of the year. Furthermore, the many astronomical alignments of the Angkor Wat impress on us the fairly elaborate system of naked-eye observations that were the basis of the temple astronomy.

But since precisely the same numbers were used in Angkor Wat as were mentioned much earlier in the Śatapatha Brāhmaṇa, one would presume that these numbers were used as a part of ancient sacred lore. Looking at Fig. 5, we see the count between the solstices has been changing much faster than the count between the equinoxes because the perigee has been, in the past two thousand years somewhere between the autumn and the winter months. Because of its relative constancy, the count between the equinoxes became one of the primary 'constants' of Vedic / Purāṇic astronomy.

The equinoctial half-years are currently about 186 and 179, respectively; and were not much different when Angkor Wat temple was constructed. Given that the length of the year was known to considerable precision there is no reason to assume that these counts were not known. But it appears that a 'normative' division according to the ancient proportion was used.

As it was known that the solar year was about 365.37 days, the old proportion of 15:14 would give the distribution 188.92 and 176.33, and that is very much the Angkor Wat numbers of 189 and 176.33, within human error. In other words, the choice of these 'constants' may have been determined by the use of the ancient proportion of 15:14.

CONCLUSIONS

It has long been known that the Angkor Wat temple astronomy is derived from Purāṇic and Siddhāntic ideas. Here we present evidence that takes us to the Vedic roots for the division of the solar year in Angkor Wat into two unequal halves. This division is across the equinoxes and that number has not changed very much during the passage of time from the Brāhmaṇas to the construction of the Angkor Wat temple, so it is not surprising that it figures so prominently in the astronomy. It also appears that the count of 189 days may have been obtained by doubling the measured period for the spring season.

The astronomy of Angkor Wat has the lesson that the medieval and ancient Indian temple complexes, which were also built with basic astronomical observations in mind, should be examined for their astronomical bases.

ACKNOWLEDGEMENT

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8. Kramrisch, S. *The Hindu Temple.* The University of Calcutta. Calcutta, 1946; Motilal Banarsidass, Delhi, 1991, p. 228.

9. Kenoyer, L.M. *Ancient Cities of the Indus Valley Civilization.* Oxford University Press, Oxford, 1998, p.57.

10. See Kak, *The Astonomical Code* ...pp. 44-46.

11. Kramrisch, S. *The Hindu Temple,* p. 51. Note that this figure is not the best modern estimate of the period of precession.

12. Boner, A., "Introduction" In Kaulācāra, R., *Śilpa Prakāśa,* Boner, A. and Rath Śarmā,, S. (eds.). E.J. Brill, Leiden, 1966, p. xxxiii.

13. SGM, p. 284.

14. Kak, S., "The Sun's Orbit in the Brāhmaṇas," *cited above.* This altar is described in detail. Note that a printing error caused the last sentence on the 4th paragraph on page 187 of this paper to become mangled. This paragraph should read: "If qne assumes that the two halves of the year are directly in proportion to the brick counts of 14 and 15 in the two halves of the ring of the Sun, this corresponds to day counts of 176 and 189. This division appears to have been for the two halves of the year with respect to the equinoxes if we note that the solstices divide the year into counts of 181 and 184."

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