ASTRONOMY OF THE ŚATAPATHA BRĀHMAṆA

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The *Śatapatha Brāhmaṇa* is analyzed and considerable new information regarding astronomy during the Vedic era is obtained. It is shown that the Vedic altars served to represent various astronomical facts. This basis is described in a cryptic form in the 10th chapter of the book entitled *Agnirahasya*. A significant new insight is the existence of a 95 year cycle of intercalation that I have called the *Yājñavalkya* cycle. It is also found that calendrical reckoning was done in 2700 year cycles of the *Saptarṣi* era

1. Introduction

Studies of Vedic ritual have noted the central place of the concept of equivalence[1,2]. These equivalences connect the elements of the macrocosmos, the microcosmos, and the altar (*adhidevata, adhyātma, adhiyajña*). Yet several details of the ritual cannot be understood unless the astronomical basis of the equivalences is stressed. This basis is described in a cryptic form in the 10th chapter of *Śatapatha Brāhmaṇa*[3], which is entitled *Agnirahasya* (Secrets of the Year). However, this basis has not yet been studied systematically. The details of this basis will be analyzed in this paper for the *agnicayana* ritual.

Geometry and mathematics of the *Śatapatha Brāhmaṇa* and the *Śulbasūtras*[4-6] are generally considered the description of the earliest science in India. Seidenberg has argued that the philosophy that equivalent altars were to have equal areas led to the posing of basic problems of geometry leading to results such as the theorem of the diagonal. He also marshals reasons why this is likely to have been known at the time of *Taittirīya Saṃhitā* itself[7]. A conservative chronology places the final form of the *Śatapatha Brāhmaṇa* to 1000-800 B.C.E. and that of the *Taittirīya Saṃhitā* to 1000 B.C.E.[8]. On the other hand, it is accepted that the myths described in the Vedas and the Brāhmaṇas deal with astronomical events of the 4th millennium B.C.E. and earlier[9,10]. New results in archaeology are compelling a revision of the conservative chronology of the Vedic literature and it is likely that the actual epochs for these books are closer to the much earlier traditional chronology[11-13]. Of the traditional accounts, the *Purāṇas* present the most conservative date for the Mahābhārata war[14], which, in the generally accepted readings, implies a date of about 1500 B.C.E. for the *Śatapatha Brāhmaṇa*. But there is an inherent

ambiguity in the *Purāṇic* statements[15-17] and the *Purāṇic* statements could be referring to an epoch of about 2400 B.C.E. On the other hand, the statement in SB 2.1.2.3 that the *Kṛttikās* never swerve from the east has been interpreted to refer to the epoch of *c*. 2950 B.C.E.

Seidenberg argues how the knowledge in the *Śulbasūtras* represents a tradition that goes back to pre-1700 B.C.E. New theories on ancient Indian chronology accept the presence of the Indo-Aryans in India in the 3rd millennium B.C.E. and earlier which is in consonance with Seidenberg's framework[12,18]. Specifically, the hydrological evidence that indicates that the Sarasvatī river, the pre-eminent river of the Vedic era, dried up around 1900 B.C.E.[19] makes this epoch the *terminus ad quem* for the early Vedic age. However, we will not consider here the issues raised by the new archaeological discoveries regarding the chronology of the Vedic literature.

Our specific goal in this article is to examine the astronomical knowledge in *Śatapatha Brāhmaṇa*. This will not only help us date the evolution of astronomy in India but also provide independent information that can help us evaluate the information from *Vedāṅga Jyotiṣa*[20], available in two recensions, the *Ṛk* (R-VJ) and the *Yājuṣa* (Y-VJ), the earliest texts devoted purely to astronomy in India. Two noteworthy discussions of the contents of the *Vedāṅga Jyotiṣas* are contained in the books by Sastry[21] and Holay[22]. Sastry ascribes the R-VJ to either 1150 B.C.E. or 1370 B.C.E., whereas Holay ascibes it to 2884 B.C.E. There are others who assign a much lower date of 500 B.C.E. to R-VJ[23]. But the framework which is used to argue this late date was based on the belief that there was no tradition of observational astronomy in India which has been shown by Billard[24] to have been incorrect. Nevertheless, owing to the difference of opinions on the development of Indian science, many histories of astronomy have ignored the Vedic contributions[25]. Just as the *Śatapatha Brāhmaṇa* was not examined for its geometrical contents until Seidenberg's research, it has not been examined for its astronomical content. No doubt this neglect is due to the prejudice that the 19th century European scholars had against the *Brāhmaṇas* due to a misunderstanding of the contents. This prejudice that plagued Indological studies for almost a century has been summarized well by O'Flaherty[26]. Likewise, Gonda[27] stresses the unreliability of the earlier theories of European scholars related to *Prajāpati* and the year as sketched in the *Brāhmaṇas*. Gonda brings together references from various texts, but he does not provide any astronomical analysis.

In this article we argue the thesis that the philosophy of equivalence, pointed out by Seidenberg in his discussion of the *Śatapatha Brāhmaṇa*, extended to number and structure and this allows us to see several Vedic texts before the *Śulbasūtras* in a new light. This philosophy was instrumental in the discovery of geometrical laws. Specifically, the development of the scientific method in India in that age was inspired by some rough parallels between the physical universe and man's physiology. This led to the notion that if one could understand man fully, that would eventually lead to the understanding of the

universe. It is important to note here that a belief that the universe is knowable had to precede the development of any empirical inquiry as to the nature of that knowledge. This led to a style of seeking metaphors to describe the unknown, which is the first step in the development of a scientific theory. A philosophy of the scientific method is already sketched in the *Rgveda*[28]. According to the *Rgvedic* sages, nature has immutable laws and it is knowable by the mind, although all representations of it in rational terms lead to a paradox. We will describe the observational framework that is likely to have led to the development of this philosophy.

Many Vedic rites went on for the full year and they were clearly meant to mark the passage of time. A considerable part of the *Satapatha Brāhmana* deals with altar construction in the *agnicayana* rite. *Agni* is the year; therefore, this rite is about a representation of the reckonings of the year. This twelve-day *agnicayana* rite takes place in a large trapezoidal area, called the *mahāvedi*, and in a smaller rectangular area to the west of it, which is called the *prācīnavamśa* or *prāgvamśa*. The *mahāvedi* trapezium measures 30 *prakrama* on the west, 24 *prakrama* on the east, and 36 *prakrama* lengthwise. The choice of these numbers appears to have been related to the sum of these three equalling one fourth the year or 90 days (SB 10.2.3.4). In the *mahāvedi*, there is built a brick altar to represent time in the form of a falcon about to take wing, and in the *prācīnavamśa*, there are three fire altars in specified positions, the *gārhapatya*, *āhavanīya*, and *dakṣiṇāgni*. The *dakṣiṇāgni* is also called the *anvāhāryapacana*, where cooking is done. In addition, 8 *dhiṣṇya* hearths are built (Fig. 1).

Agnicayana altars are supposed to symbolize the universe. *Gārhapatya* represents the earth (SB 7.1.1.13) the *dhiṣṇya* hearths represent space (SB 7.1.2.12), and the *āhavanīya* altar represents sky (SB 8.2.1.2). This last altar is made in 5 layers. The sky is taken to represent the universe; therefore, it includes space and earth. The first layer represents the earth, the third the space, and the fifth the sky. The second layer represents the joining of the earth and space, whereas the fourth layer represents the joining of space and sky. *Satapatha Brāhmana* (SB 10.4.3.9) declares that knowledge is represented through altar construction in *agnicayana*. *Agni* represents the year.

Time is represented by the metaphor of a bird. The months of the year were ordinarily divided into six seasons unless the metaphor of the bird for the year was used when *hemanta* and *śiśra* were lumped together. The year as a bird had the head as *vasant*, the body as *hemanta* and *śiśra*, the two wings as *śarad* and *grīṣma*, and the tail as *varṣā* [*Taittirīya Brāhmana* 3.10.4.1, SB 10.4.5.2][29].

A few words on the meaning of the fire ritual are in order here. In the words of Heesterman[30]:

To the Vedic thinker the whole universe was constantly moving between the two poles – of birth and death, integration and disintegration, ascension and
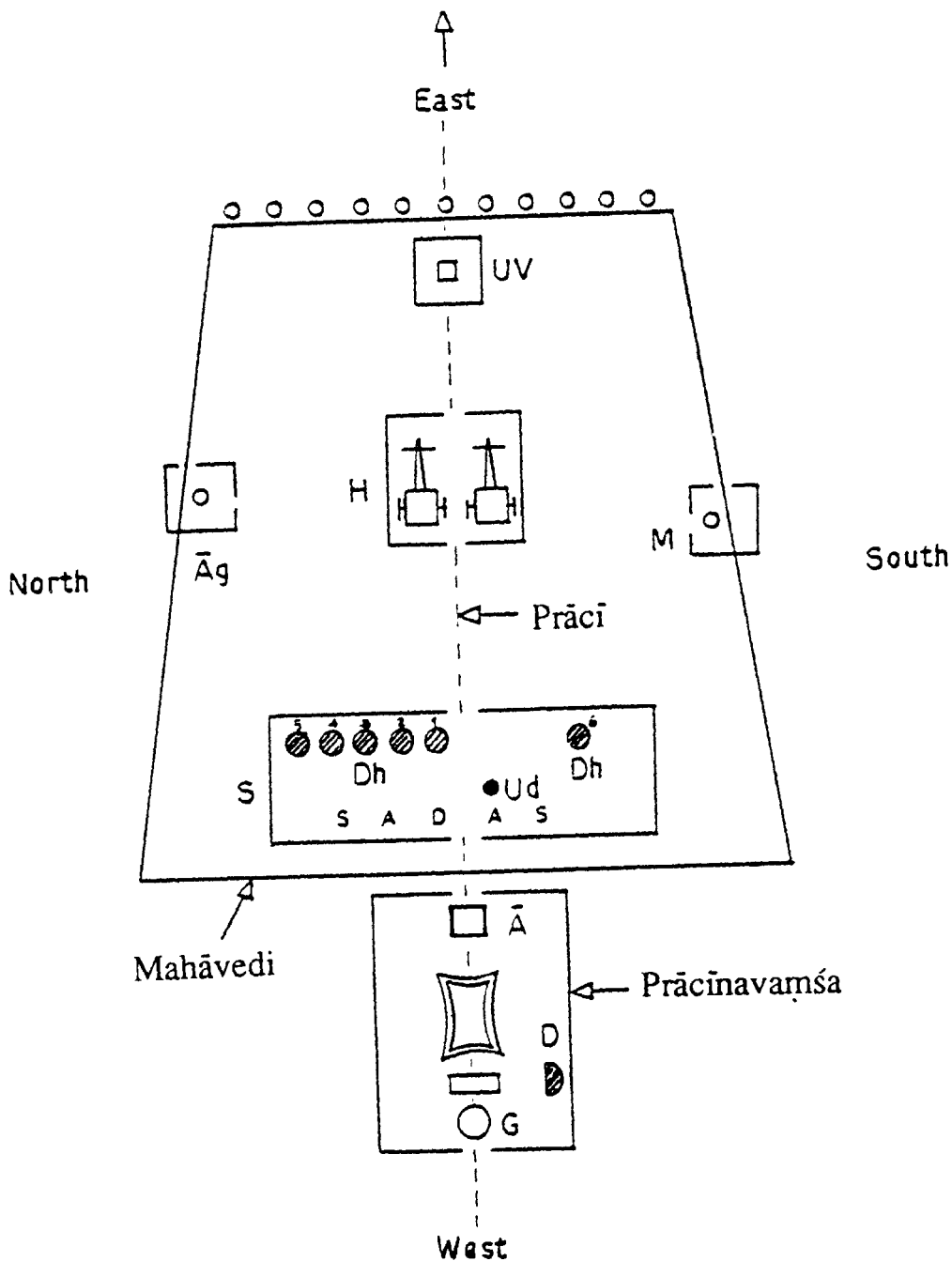
Fig. 1. The Plan for the Altars. A: *Āhavanīya*; G: *Gārhapatya*; D: *Dakṣiṇāgni*; UV: *Uttaravedi*;
Dh: *Dhiṣṇya* hearths, which include Ag: *Agnīdhra* and M: *Mārjālīya*; H: *Havirdhāna* shed

descent – which by their interaction occasion the cyclic rhythm of the cosmos... All things, entities, notions, powers, are connected with each other. Nevertheless this world is not the chaos it seems at first sight. The point at issue for the Vedic thinker is not to disentangle and differentiate conceptually different entities and notions but to realize, to know, their connections *(bandhu-)*. In the course of this process the connections converged more and more and in the end, as is shown in the *upaniṣad* texts, the intrinsic coherence of the universe was formulated in the ultimate connection *tat tvam asi...* The place of sacrifice is by virtue of the code of connections identical with the cosmos: the three fires are the three divisions of space, the course of the sacrifice represents the year.

The notion of the Vedic sacrifice is to capture the magic of change, of time in motion. Put differently, the altar ritual was meant to symbolize the paradoxes of separation and unity, belonging and renunciation, and permanence and death. The *yajamāna*, the patron at whose expense the ritual is performed, symbolically represented the universe. The ritual culminated in his ritual rebirth, which signified the regeneration of his universe. In other words, the ritual was a play dealing with paradoxes of life and death enacted for the *yajamāna's* family and friends.

Tripathi[31] has written an excellent review of the *agnicayana* rite. However, he has not tried to present an analysis of the details of the altar construction from an astronomical point of view. This is what we will present in this paper.

2. The Brāhmaṇa Texts

The *Brāhmaṇas* describe the Vedic ritual and elaborate many stories briefly noted in the *Ṛgveda*[32]. These texts can be placed in a chronological sequence based on linguistic and astronomical considerations. *Kauṣītaki Brāhmaṇa*[33] (KB 19.3) mentions that the winter solstice took place at the new moon of *Māgha*. If this were a precise determination of the solstice day, then it refers to mid-fourth millennium B.C.E. as shown by Sengupta[34]. Since we have no knowledge that such a precision existed, an error of 10 days will bring us into the 3rd millennium B.C.E. The astronomical references in the *Śatapatha Brāhmaṇa* have been interpreted by Sengupta to *c.* 2100 B.C.E. These dates do not establish that the editions of the texts that have come down to us have not been reworked subsequently. Yet an inner chronology that has the same relative order as one based on liguistic considerations is a fact of significance.

The political references indicate that *Kauṣītaki* is the oldest, since it speaks of early Vedic kings, such as *Daivodāsi Pratardana* (KB 26.5). On the other hand, Aitreya speaks of the consecration of *Bharata Dauhṣanti* (AB 8.23) by the famed sage Dīrghatamas Māmateya, but it also knows *Janamejaya Parikṣita* (AB 8.21). This latter reference places the *Aitreya* after the *Mahābhārata* battle. On the other hand, *Śatapatha* mythologizes the drying up of the Sarasvatī river in the story of Videgha Māthava and his priest Gotama Rāhūgaṇa (SB

1.4.1.10-15). This would place this text in an age somewhat after the actual drying up of Sarasvatī around 1900 B.C.E. The hydrological evidence also indicates that before this epoch, Sarasvatī had changed its course, so it is also plausible that the myth in *Śatapatha Brāhmaṇa* refers to the earlier episode. A clear reference to a Sarasvatī that is lost in the desert occurs in *Pañcaviṃśa Brāhmaṇa*[35] (PB 25.10).

3. BRICKS AND ENCLOSING STONES

Bricks to be used in altar construction were classified into two types: ordinary (*lokampṛṇā*) and special (*yajuṣmatī*). Each *yajuṣmatī* brick was consecrated in a specific manner and each such brick was marked in a unique way. Bricks were built in different shapes to different measurements.

SB 10.4.3.14-20 describes the total number of *yajuṣmatī* bricks to be 395. This was to be taken as 360 days of the year and 36 additional (including one being the fillings between the bricks) as the days of the intercalary month. By layers, the first has 98, the second has 41, the third has 71, the fourth has 47, and the fifth has 138 (SB 10.4.3.14-18). The sum of the bricks in the fourth and the fifth layers refer to the 186 (together with the one space filling) *tithis* in the half-year. The number of bricks in the third and the fourth layers equals the integer nearest to one third the number of days in the lunar year. The number of bricks in the third layer equals the integer nearest to one fifth of the number of days in the lunar year. The number of bricks in the second and the third layers equals one third the number of days in a *nakṣatra* year of 28 times $12 = 336$ days. Once the basic number of 21 is subtracted from the number of bricks in the first layer, the sum of the remainder together with the bricks in the second layer is once again the integer nearest one third the number of days in the lunar year.

The total number of *lokampṛṇā* bricks is 10,800, which equals the number of *muhūrtas* in a year (1 day $= 30$ *muhūrtas*). Of these, 21 go into the *gārhapatya*, 78 into the eight *dhiṣṇya* hearths, and the rest go into the *āhavanīya* altar.

The fire altars are surrounded by 360 enclosing stones (*pariśrita*); of these 21 are around the *gārhapatya*, 78 around the *dhiṣṇya*, and 261 around the *āhavanīya* (SB 10.4.3.13). The *āhavanīya* includes the *dhiṣṇya*; therefore, the number of days assigned exclusively to the *āhavanīya* is $261-78 = 183$ days, which is equal to the days in the *uttarāyaṇa* of a 366 day year. The choice of the 21 days for the *gārhaptya* is from the unique symbolism of this number. It is from 12 months, 5 seasons, 3 worlds, and the sun (TS 7.3.10.5, SB 7.1.1.34) or as *triṣaptā* it may refer to 'three sevens' as in *Ṛṣis*, planets, and the like (RV 10.90.15; AV 1.1.1). It may also refer to 5 *mahābhūtas* (earth, water, fire, air, space) plus 5 breaths (*prāṇa, apāna, vyāna, udāna, samāna*) plus 5 *jñānendriyas* (organs of cognition) plus 5 *karmendriyas* (organs of action) plus the *antaḥkaraṇa* (the inner air). Once the numbers 21 and 183 are chosen, the number 78 becomes the only choice for the *dhiṣṇya*.

The *dhiṣṇya* hearths are in one layer in a size of 18 *angulas* in either a square or circular form. The number of enclosing stones equals the number of bricks used in a *dhiṣṇya* hearth, and these are 8 each for five of them with the remaining three using 6, 11 and 21. The exact significance of this distribution of numbers is not clear.

The bricks and the enclosing stones also represent the meters (SB 10.1.2, 10.3.2.1-13), but we will not explore that issue here.

4. EQUIVALENCE THROUGH AREA

It is generally accepted that the measures in the *Brāhmaṇas* are the same as in the *Śulbasūtras*[36]. The important ones for our purposes are:

1 *pradeśa* = 12 *angulas*
1 *pada* = 15 *angulas*
1 *prakrama* = 2 *padas*
1 *aratni* = 2 *pradeśas* = 24 *angulas*
1 *puruṣa* = 5 *aratnis* = 120 *angulas*
1 *vyāma* = 5 *aratnis*
1 *vyāyāma* = 4 *aratnis*

The unit *pada* (foot) is sometimes taken to be smaller, being either 10 or 12 *angulas*. Furthermore, in *agnicayana*, 1 *prakrama* is taken to be 3 *padas*. But we will not go into these variant measures, since we wish to describe the normative arrangements.

Seidenberg[36] shows how the *Śulbasūtras* clearly indicate that the *gārhapatya*, the *āhavanīya*, and the *dakṣiṇāgni* are all to have the area of one square *puruṣa*. *Puruṣa* is both a linear and an areal measure; as a linear measure it may be taken to be approximately the height of a man with his arms stretched upward (say 2 metres), then as areal measure it is about 4 square metres. The size of the altars is stated in SB 7.1.1.37 and 10.2.3.1, although there is a residual ambiguity in the text about the measure being used being linear or square. The *gārhapatya* represents the womb or the earth and it is thus circular, whereas the *āhavanīya* is the sky and it is represented by a square. The *dakṣiṇāgni* is a semi-circular figure.

The *mahādevi* altars were generally made in five layers of bricks reaching to the height of the knee. Each layer in the falcon altar had 200 bricks leading thus to a total of 1,000 bricks in the five layers. It appears that the *Rgveda* knew of such an altar, because *puruṣa* is described in RV ·10.90 as "thousand headed, thousand eyed, thousand footed." In some cases, ten or fifteen layers of bricks were prescribed. The basic falcon-shaped altar had an area of $7^{1}/_{2}$ square *puruṣa*. The body of the basic falcon-shaped altar was 2 × 2 (= 4) square *puruṣas*, the wings and the tail were one square *puruṣa* each (Fig.2). To make the shape look more like that of a bird, the wings were lengthened by one-fifth of a *puruṣa* and the tail was lengthened by one-tenth of a *puruṣa* (Fig. 3). This
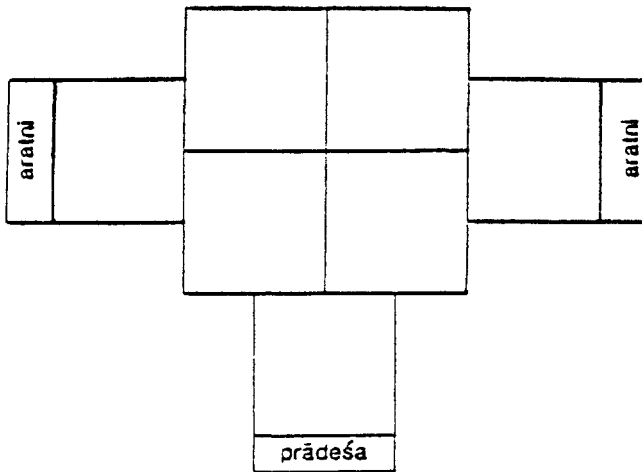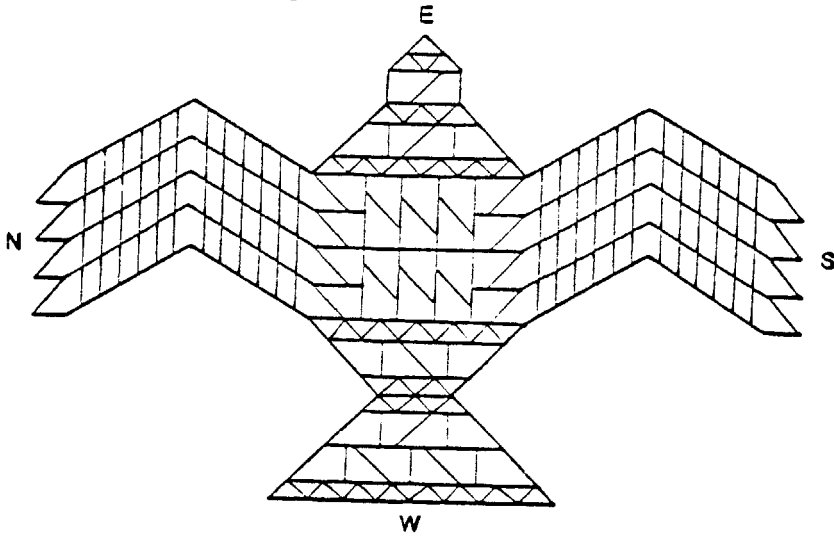
Fig. 2. The basic bird altar

Fig. 3. Variant of the basic bird altar

defined the total area of $7^1/2$ square *puruṣas* at the end of the first construction. On the second construction, the area of the altar was increased by one square *puruṣa* to a total of $8^1/2$ *puruṣas*. Further constructions successively increased the area by one square *puruṣa* at each step until one came to the "one-hundred-and-one-[and-a-half]-fold" altar. In the construction of the larger altars, the same shape as the basic altar is required and this requires solution of several geometric problems, including that of the theorem of the diagonal. It is important to note that the total number of altars to be built in a sequence is 95.

5. Equivalence through Number

The first step in abstraction requires a representation of a phenomenon through a number. If two phenomena have the same number assigned to them,

then it is reasonable to seek connections between them. Thus, a circadian biological cycle is to be linked, in a starting theory, to the earth's rotation. Likewise, monthly periods are to be linked to the phases of the moon. Equivalence through number is to be found in the earliest Vedic texts and one would expect that it must have preceded the philosophy of equivalence through area.

Consider *Aitreya Āraṇyaka*[37]. The parallels between the planetary motions and man are thus drawn:

Of bones, marrow, and joints there are 360 (parts) on (the right) side and 360 (parts) on (the left) side. They make 720 together, and 720 are the days and nights of the year. Thus, the self which consists of sight, hearing, metre, mind, and speech is like the days. [AA 3.2.1.4]

There are 360 syllables (vowels), 360 sibilants (consonants), 360 groups. What we call the syllables are the days, what we called sibilants are the nights, what we called groups are the junctions of days and nights... The syllables ... are physiologically the bones; the sibilants.... are the marrow; ... the groups are the joints [AA 3.2.2.2-7]

It is not surprising then that the *Caraka Saṃhitā* counts the total number of *asthi* (bones, teeth, nails, hard cartilages) in the human body to be 360[38]. Note, however, that according to modern anatomy, the number of bones is 206, but this does not include teeth, nails, and hard cartilages that are included in *Caraka Saṃhitā*. The underlying hypothesis in the physiology of Caraka is that somehow each *asthi* should be associated with each day of the year. Had the physicians of the Caraka school confined themselves to the gestation period of about 280 days in the womb, they would have obtained a more striking correspondence with the modern count of bones together with the teeth (milk and the permanent) and the nails. But clearly the number 360 was considered more fundamental owing to the central place assigned to the periodicity of the year in Vedic philosophy. On the other hand, if Caraka considered the bones of the child rather than the adult then he was substantially right. This is because a child has about 100 more bones than the adult that later fuse into other bones. All this constitutes a reasonable first hypothesis in the construction of a scientific theory.

An Abstract Property of Numbers: Equivalence was not held by number alone. Some of the argumentation is related to abstract relations of numbers. Thus, SB 10.4.2.1-18 indicates that 720 (the nights and days of a year) has exactly 15 factors (1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 18, 20, 24) which are smaller than the companion. This is pointed out as a parallel to 15 days of waxing and 15 days of waning of the moon.

6. AGNI AND RUDRA

Agni represents the year. But *Agni* is also *Rudra* (TS 2.2.10.4). *Agni* has three mothers (RV 7.59.12) which are earth, space, and sky. *Rudra,* similarly,

has three mothers (SB 2.6.2.14). As symbols of time, *Agni* and *Rudra* are couched in paradox. Thus, *Agni* is the father of gods, although he is their son (RV 1.69.1); he is the bull who is also the cow (RV 10.5.7). SB 6.1.3.9-17 also symbolizes a year as *Rudra, Śarva, Paśupati, Ugra, Aśani, Bhava, Mahādeva,* and *Iśāna. Śiva* is sometimes represented collectively by the eight as *Aṣṭamūrti. Rudra* wields the thunderbolt *(vajra),* which is Indra's weapon. *Agni* and *Indra* are twin brothers (RV 6.59.2). *Indra* slays his father (RV 4.18.12) and likewise *Rudra* slays *Dakṣa.* These refer to the change in the reckoning of time brought about by a precession of the earth[10,39].

Indra-Rudra or *Śiva* are sometimes represented by the world axis, the *skambha.* This is done for *Indra* even in our times, when he is represented by a pole erected during the celebrations for the new year[40].

7. THE SEVEN ṚṢIS AND THE SAPTARṢI ERA

The tradition of the seven *Ṛṣis,* the stars of the Ursa Major, in India is an ancient one and it goes back to the *Rgveda*[17].

Of those *Ṛṣis* born together, they say that the seventh is born by himself [saptatham ekajam], while six are twins, God-born *Ṛṣis [ṣaḷ idyamā ṛṣayo devajāḥ].* (RV 1.164.15; AV 9.9.16, 10.8.5)

While the *Ṛṣis* are not named in the *Rgveda,* there is a mention of *Viśvāmitra* as being God-born *(devaja)* in RV 3.53.9. References in the *Brāhmaṇas* and the *Upaniṣads*[41] suggest that the unpaired star is *Atri,* which is ε. Ursa Major, the fifth in order of listing of the stars of the group.

Puruṣa Sūkta (RV 10.90) visualizes the cosmic giant *Puruṣa* who is the basis of the world. Later, *Prajāpati* was viewed as a giant spanning the universe, framed by the constellation in the sky. *Prajāpati* was also the embodiment of the year [e.g. SB 6.1.2.19]. BU 2.2.4 represents the seven *Ṛṣis* as the lips of the cosmic person.

On the other hand, BU 2.2.4 speaks of these seven stars as representing the sense organs of the face of the cosmic person. *Gautama* and *Bharadvāja* are the ears, *Viśvāmitra* and *Jamadagni* are the eyes, *Vasiṣṭha* and *Kaśyapa* are the nostrils, and *Atri* is the tongue. That this identification was only general is borne out by the slightly different labeling in the SB 8.1.1.6-2.6, where *Vasiṣṭha* is speech, *Bharadvāja* is the mind, *Jamadagni* is the eye, and *Viśvāmitra* is the ear. This representation maps also the cognitive centers in the head as the seven *Ṛṣis.*

The later texts make a geographical identification of the *Ṛṣis* which parallels their mapping in the sky. And as the Vedic Indians spread from their original region in the Northwest India, the geographical representation of the *Ṛṣis* changed. This can be seen in the transition from the Vedic literature to the

Epic literature and the *Purāṇas*. It is in this manner that South India is associated with another *Ŗṣi* called *Agastya*, who represents Canopus.

There is a further identification of the *Ŗṣis* with the human head doubtless inspired by the identification of the primal person, *puruṣa*, in the sky.

Saptarṣi Era

SB 2.1.2.1-5 speaks of a marriage between the *Ŗṣis* and the *nakṣatras*; specifically it is mentioned that the *Ŗṣis* were married to the *Kŗttikās*. In the *Purāṇas* this notion of marriage is elaborated when it is clearly stated that the *Ŗṣis* remain for a hundred years in each *nakṣatra* (e.g. VP 2.37.413-417). It may be noted that the original core *Purāṇa* is to be dated to the same epoch as the *Śatapatha Brāhmaṇa*, but it is not clear that the elaboration in the *Purāṇas* was meant in the statement of SB 2.1.2.1-5.

The significant point here is that the *Purāṇic* elaboration implies a centennial reckoning system with a cycle of 2700 years. Such a system has been in use in parts of India for a long time that goes back centuries before C.E. and it is called the *Saptarṣi* era[42]. Each cycle of 2700 years was called a *cakra*, or cycle. By current reckoning in Kashmir, that goes back at least to Kalhaṇa, *Saptarṣi* era began in 3076 B.C.E.

Mitchiner[17], in his review of Cunningham's analysis, has suggested that the *Saptarṣi* era goes back to 6676 B.C.E. He argues that it is the beginning of this era that is quoted by the Greek historians Pliny and Arrian:

1. From Father Liber (Bacchus) to Alexander the Great, they reckon the number of their kings to have been 154, and they reckon (the time as) 6451 years and 3 months. [Pliny in *Naturalis Historia* 6.59.60][43].
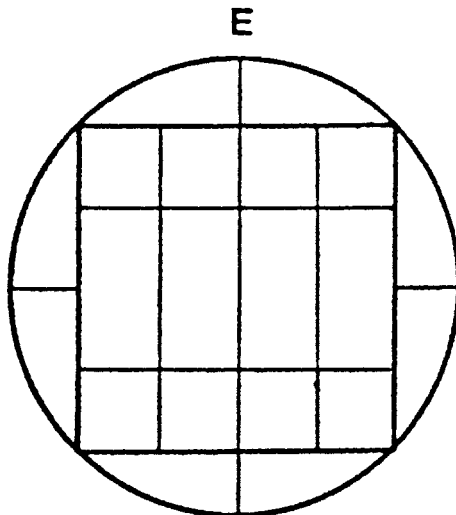

Fig. 4. The *gārhapatya*

2. From Dionysos to Sandrocottos (Candragupta Maurya), the Indians count
    153 kings, and more than 6042 years; and during this time, thrice for
    liberty*** this for 300 years, the other for 120 years. [Arrian in *Indica*
    9.9][44].

Mitchiner argues that several conflicting traditions about the Mahābhārata
war can be reconciled if it is assumed that a change in reckoning from a system
of 28 *nakṣatras* to that of 27 *nakṣatras* took place sometime after the time of
Candragupta. Mitchiner suggests that the original list of 28 *nakṣatras* (AV
19.8.2) was amended in the medieval times to 27. Since the notion of 27
nakṣatras also goes back very far as in TS 4.4.10.1-3, it is possible that the two
traditions on the Mahābhārata war go back much further than suggested by
Mitchiner.

It appears that Mitchiner's reconstruction needs to the modified in one
crucial point. It is more likely that the original system of *nakṣatras* was 27 and
that it was modified to 28 later. This modification required the change of the
beginning of the *Kali Yuga* from 2414 B.C.E. to 3102 B.C.E. The reason why
this is more likely to have happened is because it has the support of the internal
astronomical evidence, as described by Sengupta[45].

The Basis of the Saptarṣi Era: It is conceivable that the *Saptarṣi* era might
have been known during the *Śatapatha Brāhmaṇa* times. Notice that the altar is
made in an area $7^1/2$ times that of one *puruṣa*. With 360 years considered one
divine year (MP 142.12), 2700 years equal $7^1/2$ divine years. It may be that such
a theory led to the popularity of the system of 27 *nakṣatras*. It is also
significant that the epoch of 6676 B.C.E. is exactly 3600 years earlier than the
starting point of 3076 B.C.E. for the *Saptarṣi* era as accepted now. Since it is
clear that at the time of the Mauryas, the cycles of the *Saptarṣi* were counted
back to 6676 B.C.E., it appears that the new count that goes back to 3076
B.C.E. was started later to make it as close to the start of the Kali era as
possible.

8. PRAJĀPATI

The *Śatapatha Brāhmaṇa* speaks of the seven *Ṛṣis* creating seven persons
in the beginning, who are later assimilated into one person. This is represented
by the fire-altar (*Agni*) who is *Prajāpati*, where the body represents four and
the wings and the tail the other three [SB 6.1.1.5-6]. Elsewhere (SB 10.6.4.1),
Prajāpati is represented as a horse. This horse is also a metaphor for the sun.
Aśvamedha sacrifice is to memorialize, to transcend time.

In the *Bṛhat Saṃhitā* of Varāhamihira (550 C.E.), stellar *Puruṣa* is
described fully. The feet of this *nakṣatra Puruṣa* are represented by the
asterism *Mūla*, the shanks by *Rohiṇī*, the knees by *Aśvinī*, the thighs by the
two (*Pūrva* and *Uttara*) *Aṣāḍhās*, the sex organs by the two (*Pūrva* and *Uttara*)

Phalgunīs, the hips by *Kṛttikā*, the sides by the two (*Pūrva* and *Uttara*) *Bhadrapadās*, the stomach by *Revatī*, the breast by *Anurādhā*, the back by *Dhaniṣṭhā*, the arms by *Viśākhā*,   the hands by *Hasta*, the fingers by *Punarvasu*, the nails by *Āśleṣā*, the neck by *Jyeṣṭhā*, the ears by *Śravaṇa*, *the mouth by Puṣya, the teeth by Svāti*, laughter lines by *Śatabhiṣaj*, the nose by *Maghā*, the eyes by *Mṛgaśiras*, the forehead by *Citrā*, the head by *Bharaṇī*, and the hair by *Ārdrā*. [*Bṛhat Saṃhitā* 105.1-5][46].

Prajāpati is a metaphorical representation of time. *Prajāpati* is also the year (SB 5.1.1.1). So, time was represented by the constellations in the sky or the processes of life and death in the world. The fire altar is a symbolic representation of time in relation to man. According to the *Baudhāyana Śulbasūtra*[47] 7.17 the bricks can be replaced by *mantras* leading thus to the *chandaścit*. The year was thus represented by the Vedic stanza called *bṛhatī*, which consists of 36 syllables forming four verses divided into two *hemistichs* (8, 8, 12, 8) (SB 6.4.2.10). Elsewhere (SB 1.3.5.9), it is stated that by using 15 *gāyatrī* stanzas (of 24 syllables each) one obtains the days of the year and the year.

The fact that precession of the earth's axis caused the seasons to change slowly with time was expressed by myths such as that of the decapitation of *Prajāpati* by *Rudra*. Due to the precession of the earth, *Prajāpati*, the year, marked by the sun rising in Orion at the vernal equinox, had moved toward *Rohiṇī*, his daughter. This is metaphorically represented by the slaying of *Prajāpati* by *Rudra*. Much earlier, a similar passage was represented by the myth of *Vṛtra* being slain by *Indra*. *Indra* and *Rudra* represent the same frame of time at different epochs. Another similar myth is that of the creation of a new world with its own axis by Viśvāmitra[9]. The frame of time was represented in *Atharvaveda* as *skambha*, the cosmic pillar (AV 10.7).

The identification of the year and man was carried on further than that of 360 days and 360 *asthis*. Śatapatha B. (12.3.2.5) speaks of the year having 10,800 *muhūrtas* (1 *muhūrta* = 48 minutes). Also note that 1 *puruṣa* = 120 *aṅgulas* and, therefore, the area of $7^{1}/_{2}$ sq. *puruṣa* for the basic altar equals 108,000 square *aṅgulas*.

The *Ṛgveda* had long spoken of *Puruṣa* (or *Prajāpati*) having a 1,000 fold nature. The year was, therefore, represented in terms of 5 layers of 200 bricks each. On the other hand, SB 7.4.2.31 explains that the 5 layers represent the 5 seasons of the year.

But the most significant observation from the *agnicayana* ritual is that it described a 95 year cycle as represented by the altars going from the size of $7^{1}/_{2}$ square *puruṣa* to $101^{1}/_{2}$ square *puruṣa*. Since tradition ascribes the authorship of the *Śatapatha Brahmaṇa* to *Yājñavalkya* (Mahābhārata 12.11739), this may be called the *Yājñavalkya* cycle. This cycle is obviously the product of 5 × 19.

9. THE ASTRONOMICAL FRAMEWORK

To understand the astronomical references in *Śatapatha Brāhmaṇa*, it is essential to summarize relevant references in other co-eval or earlier Vedic texts. A good summary of Vedic astronomy is to be found in Shukla[48].

The *Ṛgveda* describes the universe to be infinite. It also refers to the five planets as gods and mentions *Bṛhaspati* (Jupiter) and *Vena* (Venus) by name (e.g. RV 4.50.4 & 10.123.1). The moon's path was divided into 27 equal parts, although the moon takes about $27^1/3$ days to complete it. Each of these parts was called a *nakṣatra*. *Nakṣatras* are mentioned in the *Ṛgveda* and *Taittirīya Saṃhitā* (TS 2.3.5.1-3) specifically mentions that they are linked to the moon's path. RV 10.55.3 mentions the 34 lights, which are apparently the sun, the moon, the five planets, and the 27 *nakṣatras*. In later literature, the list of *nakṣatras* was increased to 28. Constellations other than the *nakṣatras* were also known. RV 1.24.10; 10.14.11; 10.63.10 mention the *Ṛkṣas* (the Bears), the two divine Dogs (Canis Major and Canis Minor), and the Boat (Argo Navis). The constellation *Tiṣya* is invoked in RV 10.64.8. But since TS 2.2.10.1-2 says *Tiṣya* is *Rudra*, perhaps Sirius is meant. *Aitreya Brāhmaṇa* (AB 3.33)[49] speaks of *Mṛga* (Orion) and *Mṛgavyādha* (Sirius). TS 3.4.7 calls the moon *sūrya raśmi*, one that shines by sunlight.

In analogy with a civil day, a lunar day was reckoned from one moonrise to another and it was called a *tithi*. The lunar or synodic month was measured from full moon to full moon or from new moon to new moon (TS 7.5.6.1). Twelve lunar months constituted a lunar year. The lunar month consisted of 30 lunations (BU 1.5.14). To preserve correspondence between lunar and solar years, intercalary months were inserted at regular intervals (see e.g. RV 1.25.8).

For ready reference, note the following facts from modern astronomy:

Solar year = 365.25636 solar days
Moon's sidereal period = 27.32166 solar days
Lunar month = 29.530588 solar days = 30 *tithis*
Lunar year = 354.367 solar days
Tithis in a solar year = 371.06239

The solar year was known to be a little more than 365 days, although its nominal period was taken to be 360 days. TS 7.1.10.1-3 speaks of the 5 excess days over the *Sāvana* year of 360 days to complete the seasons, where 4 days are too short and 6 days are too long. TS 7.2.6.1 speaks of the extra 11 days (*ekādaśarātra*) over the 12 lunar months of 354 days required to complete the year. That the reckoning was done both by the solar and the sidereal or *nakṣatra* counts is clear from the references to the year having 13 months (SB 7.1.1.32 or 7.2.3.9). Later books, such as the *Nidāna Sūtras*, speak clearly of the *nakṣatra* year being equal to 324 days, which is 27 times 12[50]. In a system of 28

nakṣatras the *nakṣatra* year equals 336 days. That *Śatapatha Brāhmaṇa* knows the *nakṣatra* year will be shown when we discuss the falcon altar again.

The eleven extra days in the solar year, when compared to the lunar year, were each assigned a separate god. A triple division of space and time is a common *Ṛgvedic* theme. *Ṛgveda* speaks of the three-fold world which then leads to a total of 33 gods. RV 7.87.5 speaks of three earths.

To get further information on the length of the solar year, one can use evidence regarding the extent of intercalation needed after the nominal year period of 360 days. Was the year taken to be 365 days or 366 days? With 366 days one would require intercalation of 12 days a year, whereas 365 days imply intercalation of 11 days. SB 10.5.4.5 describes the 756 bricks to be used in building the fire altar. These represent the 720 lunar days and nights followed by the 36 lunar days and nights in the intercalary month. This supports an intercalation of 18 days every $1^1/2$ years. In other words, the basic year was taken to be 366 days, which would correspond to 372 *tithis*. But the *ekādaśarātra* also points to 365 days or 371 *tithis*. The only conclusion to be drawn is that the true length of the year was known to be between 365 and 366 solar days, or equivalently 371 or 372 *tithis*. This is corroborated by RV 4.33.7; we hear about the *ṛbhus*, the receptacles of time (RV 1.111.1; 4.34.9) who rest for 12 days after the year is over.

Further support for this is obtained from RV 3.9.9, which speaks of a total of 3339 gods in a year, personified as *Agni*. This corresponds to 371 *tithis* if one recognizes that in *Vedāṅga Jyotiṣa* each *tithi* is equated to 9 *bhāṃśas*.

The period of 5 solar years was called a *yuga*. These years were named *saṃvatsara, parivatsara, idāvatsara, idvatsara,* and *vatsara* (TS 5.5.7.3; SB 8.1.4.8) or minor variations of these names. A five year period was convenient, because it led to two intercalation months of 30 *tithis* each, which the *Vedāṅga Jyotiṣa* evidence suggests were added at intervals of $2^1/2$ years. But this would lead to an excess of about 4.75 *tithis* in 5 years, necessitating further corrections in greater periods.

The *Taittirīya Brāhmaṇa* (TB 3.9.22) calls the year the day of the gods. This indicates how increasing larger *yugas* would have been conceived.

10. THE 95 YEAR YĀJÑAVALKYA PERIOD

SB 6.1.1.1-3 speaks of how the *Ṛṣis* (here they are vital airs) created seven separate persons, who doubtlessly represent the seven cognitive centres. Now they made these seven persons into one person and this is represented by the seven (and a half) *puruṣa* altar. SB 10.2.3.18 now describes the process of building larger altars: "*Prajāpati* was created sevenfold in the beginning. He went on constructing (developing) his body, and stopped at the one hundred and

one fold one." Later it is added that "the one hundred and one fold altar becomes equal to the seven fold one" (SB 10.2.4.4).

BS 5.6 speaks of how the altar at the mth augmentation is obtained with the new unit x after such augmentation satisfying $x^2 = 1 + (2m/15)$, where m runs from 1 to 94. The $101^1/_2$ square *puruṣa* altar is obtained when $m = 94$ and for this $x^2 = 13^8/_{15}$. Now SB 10.2.3.11 describes a "ninety-eight-fold" bird as having dimensions of 14 square *puruṣa* and Seidenberg[6] convincingly shows that this must have referred to the $101^1/_2$ square *puruṣa* altar.

The *agnicayana* ritual leads to a cycle of 95 years, as explained. The logic behind this cycle is that this leads to exactly 35 intercalary months (with a residual small error) in 95 years if the year is counted as 360 *tithis*. In Section 12, we show that 95 years represent a big period even when the year is taken to be a *nakṣatra* year of 324 days. If each altar is taken to represent a *yuga*, the cycle would then become 475 years.

The use of the *Yājñavalkya* cycle at a later time is corroborated by the creation of the 2850 year cycle in the *Romakasiddhānta*, which is 30 times 95, or a "month" of such a cycle.

11. THE GREAT YUGA

PB 25.17.1 speaks of how the world is set in motion after a 1000 year sacrificial rite (*sahasrasaṃvatsarasattram*) of *Prajāpati*. SB 10.4.4.2 speaks of the number of stars in the sky being equal to the number of *muhūrtas* (1 day = 30 *muhūrtas*) in 1,000 years or $1000 \times 360 \times 30 = 10,800,000$. This is followed by consideration of *muhūrta* as a basic measure in the consideration of the grand year of 1,000 ordinary years. A *muhūrta* is to a day what a day is to a month. In other words, the grand year consists of 10,800,000 units, which were presumably taken to correspond to years. Note also that PB 16.8.6 and PB 21.1.9 declare that the sun is 1000 earth diameters away from the earth.

Since the area of the basic altar is 108,000 in square *aṅgulas*, we see a representation of a square *aṅgula* as being equal to 100 years.

That *Ṛgveda* was in itself taken to represent a symbolic altar of *mantras* is confirmed by the number of syllables in the *Ṛgveda*. SB 10.4.2.23 describes the Ṛk-verses to be 12,000 *bṛhatīs*, and since each *bṛhatī* has 36 syllables, this totals 432,000 syllables. Another way to count the syllables is by the 10,800 *paṅkti* verses. With 40 syllables to a *paṅkti*, it adds up to a total of 432,000 syllables. *Yajurveda* and *Sāmaveda* were supposed to add up to another 432,000 syllables in a proportion of 2:1. Altogether these three Vedas add up to 864,000 syllables.

12. MORE ON ALTAR DESIGN

The important *gārhapatya* altar, that represents earth or the womb, has an area of 1 square *puruṣa* which equals 14,400 square *aṅgulas*. This requires drawing a circle around a square of side 1 *vyāyāma* (1 *vyāyāma* = 4/5 *puruṣa*). It is constructed with 21 bricks in each layer (SB 7.1.1.34). With $7^1/2$ square *puruṣa* considered equal to 360 days, the area of the *gārhapatya* altar equals 48 days. It is also noteworthy that the *gārhapatya* design as in Fig. 4 implies a value of $\pi = 25/8$. Also note that this design uses 20 bricks and the cement used to bind these 20 bricks is taken to be the 21st brick (SB 7.1.1.33).

Note also that the falcon altar is *Prajāpati*, the year. It symbolizes all the three years: *nakṣatra*, lunar, and solar. The increase in the area in each new construction of the falcon altar is 1 square *puruṣa*, which equals 48 days. The purpose of the increase is to make the altar become closer to the actual year. If the *nakṣatra* year is now taken to be 324 *tithis*, the additional 48 *tithis* are needed to make it exactly equal to the nominal year of 372 *tithis*. On the other hand, it may indicate the size of a larger *yuga* by the following correspondence:

1 *tithi* = 9 *bhāṃśas* like 1 year (371 *tithis*) = 3339 *bhāṃśas;*
48 days expands to a larger period of 48 × 9 = 432.

This multiplier of 9 may have also been used in going from 12 months to a period of 108.

The expansion of 48 *tithis* is required every year, since it is clearly stated that the expanded altar is to be viewed as before as *Prajāpati*. Since we do know that the number of *tithis* in a year is supposed to be 371.06239, this implies an excess of 0.93761 *tithis* per year. In 95 years, this excess would be almost exactly equal to 89 *tithis*. It appears that the period of 95 years was chosen because observationally the excess was taken to be 90 *tithis* or 3 lunar months. Every 95 years a major adjustment of the calendar would then have been required.

13. CONCLUSIONS

The equivalences by number were at the basis of the altar as the year. This allows us to obtain considerable knowledge about the astronomy of the era of the *Śatapatha Brāhmaṇa*. In particular we find a 95 year cycle as a part of the *agnicayana* ritual. The areas of the fire altars correspond to the broad astronomical facts about the year. But this exact distribution of the various kinds of bricks needs to be further studied. The fact that the altar increases by one unit area in each new construction indicates the intercalation that is necessary to bring the *nakṣatra* year in line with the solar year. This increase goes on until the 95th year, when an additional correction would have been made to remove this error. The details of the altar design represent, in code, astronomical facts;

we have sketched broad aspects of this code, but the details of it are yet to be deciphered.

In other words, we find that the main elements of the astronomy of *Vedāṅga Jyotiṣa* are already contained in *Śatapatha Brāhmaṇa* and earlier books. Specifically, we find clear references to the nominal year of 372 *tithis,* the *nakṣatra* year of 324 *tithis,* and a solar year of 371 *tithis.* The choice of 371 *tithis* for the solar year corresponds to 365.1949 days. But the fact that a further correction was required in 95 years indicates that these figures were in themselves considered to be approximate. Therefore, the dating of *c.* 1150 to 1370 B.C.E. for R-VJ is not inconsistent with a conservative dating of 2nd millennium B.C.E. for *Śatapatha Brāhmaṇa.* Of course, *Śatapatha Brāhmaṇa* does not speak of any details of motions of planets, but that is not surprising considering that its main purpose is ritual.

The clear conception of the great *yuga* during the age of the *Brāhmaṇas,* as also the notion of the *puruṣa* being made out of $7^1/2$ *puruṣas,* when a *puruṣa* is also equated with 360 years leading to a longer cycle of 2700 years, indicates that the *Saptarṣi* era was known then. This increases the significance of the astronomical evidence from the Vedic literature that has been analyzed by Sengupta and others.

One must also note the centrality of time in the philosophy of the texts. Time was considered the ground on which a perception of space was made as in "space is *Prajāpati*" (SB 8.4.1.1). Time could be marked in different ways and so "*Prajāpati,* the year, is *Agni* and King *Soma,* the moon" (SB 10.4.2.1). The relativity of time was proclaimed by stating that before *Prajāpati,* the year, there existed nothing but the realm of the pitch-dark.

ABBREVIATIONS FOR VEDIC AND PURANIC TEXTS

AA	*Aitreya Āraṇyaka*
AB	*Aitreya Brāhmaṇa*
AV	*Atharvaveda*
BS	*Baudhāyana Śulbasūtra*
BU	*Bṛhadāraṇyaka Upaniṣad*
KB	*Kauṣītaki Brāhmaṇa*
MP	*Matsya Purāṇa*
PB	*Pañcaviṃśa Brāhmaṇa*
RV	*Ṛgveda*
SB	*Śatapatha Brāhmaṇa*
TB	*Taittirīya Brāhmaṇa*
TS	*Taittirīya Saṃhitā*
VJ	*Vedāṅga Jyotiṣa*
VP	*Vāyu Purāṇa*

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