4 ASTRONOMY IN INDUS CIVILIZATION AND DURING VEDIC TIMES

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Primitive civilizations recognized the fact that different constellations are visible at different times of the year. The appearance of conspicuous stars or groups of stars in conjunction *(amāvasyā)* or opposition *(pūrṇimā)* with the Moon or Sun was considered to be reliable guides for the fixing of agricultural and religious practices. Scientific astronomy in India perhaps began with the use of such astronomical phenomena. Many religious festivals in India are still found to be associated with the phases of the Moon *(tithi)*—an association which thus acquired a deeper significance. India, like Egypt and Mesopotamia, originally had a lunar calendar in the time of the Indus civilization. In Vedic and post-Vedic times, the Sun gradually assumed greater importance because of the emphasis on agriculture and seasons. Consequently the attempt in the Vedic period to associate the lunar months in a more or less fixed fashion with the agricultural seasons led to the development of a luni-solar calendar in the post-Vedic period. The luni-solar calendar involved the addition from time to time of an intercalary lunar month to the regular (civil) months of fixed length (of 30 days). These intercalations were handled in a practical manner, whenever deemed necessary, to ensure that seasonal festivals and agricultural practices did not go out of step. Methods of intercalations varied over different parts of the country.

NEW YEAR FESTIVAL

Parpola and his colleagues have studied the astronomy of the Indus civilization.[1] This was later re-examined by Asfaque.[2] These scholars believe that various figures of animals, real or mythological (bulls, elephants, rams, rhinoceroses, crocodiles, tigers, unicorns, animals with composite head etc.) and deities in human form, found in Indus seals, signify a crude system of the division by asterism of the apparent path of the Moon. Father Heras[3] first associated the sign  with the Dravidian word *min* for fish, and its homophone signified an asterism. Parpola *et al.* also supported this dual system of interpretation of star worship and fish cult which was probably based on the concept that the sky was garbed by the oceans or a broad river in which the stars were nothing but the swimming fishes. The proper assessment of the extent of astronomical knowledge, however, must await the decipherment of all the seals.

Our knowledge about the new year festival of the Indus people is based on the depiction on a seal (M. 2430) found in the D. K. area Mohenjo-daro. This seal demonstrates how religious ritual and astronomy went hand in hand in these distant prehistoric times. The Vedic period also records similar offering ceremonies such as

the *sāvana* (thrice a day), the *aha* (daily sacrifice from sunrise to next sunrise), the *saḍaha* (six *ahas*), the *māsa* (five *saḍahas*), and the *samvatsara-satra* (twelve *māsas*). The important pictographs on the Mohenjo-daro may be described as follows:

(i) a deity standing at the central place between two similarly inclined branches of a pippal tree; (ii) in front the deity there is a raised structure, perhaps an altar; (iii) seven other human figures standing in a row in the lower portion of the seal in such a way that the deity, the altar and the central human figure apparently come in one line denoting perhaps east-west; (iv) a priest kneeling before the altar; (v) the picture of a huge stag or ram with two long heavy horns having a human face; (vi) the head-dress of all human figures resembles the traditional Indian turban; and (vii) several pictographs include the fish symbol (Fig. 4.1).

Fig. 4.1

What do the seven human figures represent? Parpola[4] writes, "I was previously thinking that the seven figures in the seal (M. 2430) most probably are seven sages of the Great Bear. I have later changed my view, and now think that they are probably the stars of Pleiades. The conclusion, however, is not based on the seal, but on studies of the Vedic and Epic mythology and the connection of Skanda with the Pleiades, also in the Indus script". Moreover, Parpola considers the representation on the seal to be the new year festival with autumnal equinox at the full-moon at Kṛttikā, while Asfaque compares it to the vernal equinox at Kṛttikā. In fact, Harappan-Ṛgvedic and Mohenjo-daro Atharvavedic cultural traditions have been

emphasized by many historians. According to the Vedic tradition,[5] Kṛttikā comprises of seven stars, viz. Ambā, Dulā, Nitatnī, Abhrayantī, Meghayantī, Varṣayantī and Cupunikā. The *Śatapatha Brāhmaṇa*[6] reports that Kṛttikā never deviates from the east. The actual east-west line might have been determined by the shadow of the pole on the equinox day and verified by the rising and setting points of the star Kṛttikā.[7] The fixation of east-west line also played a significant role in the construction of Vedic altars. At present, Kṛttikā does not appear to rise exactly in the east but at a point north of east. Obviously the lower portion of the seal represents the eastern sky.

In the western side is found a handsome, ever-young god between the two pippal branches. The symbol of branches appears to be meaningful, for in Sanskrit the word *śākhe* means two branches of a tree. Hence the symbol is of special significance and represents possibly the asterism Viśākhā. This again becomes clear from the fact that Viśākhā and Kṛttikā are opposite constellations (*vide* table of the lunar mansions). The handsome figure between the two branches shows that he is in conjunction with Viśākhā. Parpola considers the handsome ever-young war-god as Skanda, the heavenly counterpart of Viśākha, while Asfaque is inclined to think that it represents the Moon in its dark phases and invisible to the eye at the epoch of the new year.[8] From the prominent crescent horn and beautiful ever-young feature it is quite suggestive that the god represents 'Moon' not war-god 'Skanda'. The presence of Kṛttikā in the eastern horizon suggests that the full-moon rises at Kṛttikā and sets at the opposite asterism Viśākha. So the ending part 'Moon in the dark phases' does not appear to be correct. This is perhaps the last hour festival of the night after it began its journey with full-moon at Kṛttikā. In the centre of the seal is found a man worshipping before an altar. At the back of the priest, there is the figure of a huge stag (in Sanskrit, *mṛga*) with two big horns *(śiras)*. The stag on the seal is represented as the asterism Bharaṇī and Aśvinī both by Parpola and Asfaque on the basis of the hypothesis that they are situated west of Kṛttikā, and their place in the sky is much higher above the eastern horizon than that of the former at the time of the heliacal observation. The star *mṛga* is described in masculine gender in the *Atharvaveda*[9] and the ceremony shows that the priest is introducing Mṛgaśiras which is known as the month of Agrahāyanī in the Vedic tradition.[10] The Agrahāyanī derives its meaning, from the following: "the year *(hāyana)* stood at the end *(agra)* of that *nakṣatra* night". Agrahāyanī as a synonymous term for Mṛgaśīrṣa *nakṣatra* occurs in Pāṇini at three places.[11] There are references at two places in the *Mahābhārata*[12] to the effect that the list of months begins with the Mārgaśira. Al-Bīrūnī[13] has recorded that, in Sind and other provinces, the year commenced with the Mārgaśiras, and the system of bearing the year with Mārgaśiras must have remained in vogue in some provinces in west India for some time. The stag *(mṛga)* is so prominent on the seal as to make it highly probable that the months of Agrahāyani were already introduced in Indus times. This again shows that the *kṛttikādi* system was current during the Indus Valley civilization. The new year began with Kṛttikā on the equator (equinoxial day), and the month was *pūrṇimānta*. The remaining symbols of the seal (M. 2430) have been considered by Parpola and his colleagues as ritualistic paraphernalia on the occasion of the year beginning.

LUNAR MANSION AND LUNAR MONTHS

From the foregoing discussion it appears that the months Mṛgaśīrṣa (Agrahāyanī) were being introduced after the full-moon at the Kṛttikā (*kṛttikādi* system). Further, Kṛttikā was considered as the east point on the equator or equinox point when day and night were equal. The months were also *purṇimānta*. The month-names, Kārttika, Agrahāyanī (Mṛgaśīrṣa), Pauṣa, Māgha, etc. directly follow from the star names Kṛttikā, Mṛgaśīrśa, Puṣyā, Maghā respectively. Moreover, the identification of Kṛttikā and Viśākhā asterisms in opposition indicates that possibly 27 or 28 asterisms were already known in time of the Indus civilizations. The *Atharvaveda*[14] and the other Vedas[15] have followed the *kṛttikādi* system and given also a complete list of 27 or 28 lunar asterisms. The tradition of the system of *nakṣatras* and lunar months based on them is very old. The details are tabulated as follows:

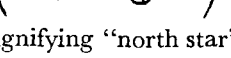
Nakṣatra (*Nirayana* Longitude)[16]	*Lunar months*
1. Kṛttikā (Alcyon, 36° Long)	Kārttika
2. Rohiṇī (Aldebaran, 46°)	
3. Mṛgaśīrṣa (λ Orionis, 60°)	Agrahāyanī
4. Ārdrā (Betelguese, 65°)	
5. Punarvasu (Pollux, 90°)	Pauṣa
6. Puṣyā (δ Cancrii 105°)	
7. Āśleṣā (Hydras, 99°)	
8. Maghās (Regulas 126°)	Māgha
9. (Pūrva) Phalguni (δ Leonis, 138°)	
10. (Uttara) Phalguni (Denebola, 148°)	Phalguni
11. Hasta (δ Corvi, 170°)	
12. Citrā (Spica, 180°)	Caitra
13. Svātī (Arcturus, 181°)	
14. Viśākha (α Centauri, 216°)	Vaiśākha
15. Anurādhā (δ Scorpi, 219°)	
16. Jyeṣṭhā (Antares, 226°)	Jyaiṣṭha
17. Mūla (λ Scorpii, 241°)	
18. (Pūrva) Aṣādhā (δ Sagittarii, 251°)	Āṣāḍa
19. (Uttara) Aṣādhā (δ Sagittarii, 259°)	
20. Abhijit (Vega, 262°)	
21. Śroṇā (Altair, 278°)	Śrāvaṇa
22. Śraviṣṭhā (β Delphini, 293°)	
23. Śatabhiṣā (λ Aquarii, 318°)	
24. (Pūrva) Proṣṭhapadā (Markob, 330°)	Bhadrapadā
25. (Uttara) Proṣṭhapadā (ν Pegasi, 346°)	
26. Revatī (ζ Piscium, 356°)	
27. Aśvayujau (β Arietis, 10°)	Āśvina
28. Bharaṇī (41 Arietis, 25°)	

ORIGIN AND CONFIGURATION OF THE UNIVERSE, STARS AND PLANETS

The ideas of the Indus Valley people on the origin and the configuration of the universe are not yet known. The *Ṛgveda*[17] mentions: "From the watery ocean was born the year *(samvatsara)* ordaining days *(aha)* and night *(rātri)*, the controller of every living moment. The creator then created, in due order, the Sun *(sūrya)*, the Moon *(candra)*, the sky, the regions of air and light". Similar passages are found in the *Taittiriya Brāhmaṇa*[18] and the *Taittiriya Upaniṣad*.[19] Though in some passages the Vedas describe the creation of the world and the order of creation, doubt has also been expressed in various passages of the *Taittiriya Brāhmaṇa*[20] where it is pointed out that no one can say the actual cause of creation, which implies that no one knows the order in which the creation took place.

Some time the universe has been stated to be made up of the earth and sky *(dyāvā pṛthivī)*, but more often it is referred to as consisting of three parts,[21] viz. earth *(bhūmi)*; the atmosphere *(antarikṣa)* and the sky *(dyau)*. The universe is also conceived as infinite in extent.[22] The *Taittiriya Saṃhitā*[23] notes that fire rests with the earth, air in the atmosphere, Sun in the sky and Moon in the company of constellations *(nakṣatrebhyaḥ)*.

The *Ṛgveda* refers to the five planets as the five gods[24] and mentions Bṛhaspati (Jupiter) and Vena (Venus) by name.[25] It also mentions the thirty-four lights[26] which, in all probability, are the Sun, Moon, the five planets and twenty-seven *nakṣatras*. Parpola considered the crab symbol as indicative of planets because of its occurrence in samples in most cases before and after various fish signs of Indus inscriptions. The Tamil word, *kol* for planet also means 'to seize' or 'seizure' giving emphasis on the claws rather than on the feet. The Sanskrit word *graha* for planets has also the same meaning. This indicates that the Vedic people received the pre-*Ṛgvedic* traditions of the Indus civilization.

The Indus script () has been accepted by Parpola to signify *vaṭa-mi*in old Tamil, signifying "north star". Vedic seers knew certain other constellations, e.g. Ṛkṣas (bears), meaning possibly two north polar constellations, the Great Bear and the Little Bear[27]; two heavenly dogs identified with Canis Major and Canis Minor[28]; the divine boat signifying the constellation of Navis.[29] The Great Bear was also known as the constellation of seven sages, *saptarṣi*.[30] The *Aitareya Brāhmaṇa*[31] has narrated an interesting story regarding the constellation Mṛga (Orion) with the star Mṛgavyādha (Sirius).

The Sun is conceived as the prime supporter and controller of the world as well as sole lord and light-giver of the universe.[32] The Sun also controls the seasons and causes the winds.[33] It further generates all earthly directions.[34] There is reference to only one Sun and not more as the lord of the universe.[35] The Sun is considered as the maker of the day and night; the duration of day light from sun-rise to sun-set is

taken as the day" and that of darkness from sun-set to sun-rise as the 'night'. The variability of the length of day and night was also known.

The Moon is spoken of as the light of the Sun *(sūrya-raśmi)* meaning that it shines by the Sun's light.[36] It is as bright[37] as the Sun and appears in new forms day after day in different phases.[38] Some phases[39] are well-known, e.g. "full-moon day *(rākā)*, the day previous to full-moon *(anumati)*, new-moon day *(kuhū)*, the day preceding the new-moon *(sinīvāli)*. The *Taittiriya Brāhmaṇa*[40] gives a full list of names of fifteen days of the light half *(pūrva pakṣa)* and also of dark half *(aparapakṣa)* of the Moon. Day and night is each divided into fifteen *muhūrtas*. Each *muhūrta* is again divided into fifteen *pratimuhūrtas*.[41]

The period from one moonrise to the next or from one moon-set to the next was known as a *tithi*[42] (lunar day) in the Vedic period, which is somewhat different from our present concept of a *tithi* of fixed time. That the phenomenon of new- and full-moon is related to Moon's elongation from the Sun was also correctly guessed. The invisibility of the Moon on the new-moon day is explained by its being swallowed by the Sun and its appearance on the following day by its being released by the Sun.[43]

UNIT OF TIME

The year *(samvatsara)*, month *(māsa)*, six days week *(ṣaḍaha)* and day *(aha)* were considered as basic units of time. There were various units of year lengths known in ancient India, a few of which are summarized below :

1. Sidereal *(nākṣatra)* lunar year of 324 days=27 *nakṣatras* of 12 days average duration each. The number was possibly derived from the practical counting of the moon through *nakṣatras*.

2. Sidereal *(nākṣatra)* lunar year of 351 days=27 *nakṣatras* of 13 days average duration each.

3. Synodic (similar position of the Moon relative to Sun) lunar year of 354 days $= 6 \times 30$ days $+ 6 \times 29$ days
$= 12 \times 29\frac{1}{2}$ days.

   For practical consideration, the first half of the six months was possibly considered to be of 30 days and the second half of 29 days. The average lunar month contains $\frac{1}{12}(6 \times 30 + 6 \times 29)$ or $29\frac{1}{2}$ days. The Moon becomes full after 29 or 30 days.

4. Civil *(sāvana)* year of 360 days $= 12 \times 30$ days
$= 12 \times 5$ *ṣaḍahas* (1 *ṣaḍaha* $= 6$ days)
$= 360$ days.

This refers to the mean motion of the Earth round the Sun. The *Ṛgveda*[44] has compared 12 months to 12 spokes of a wheel, 360 days to 360 nails, and describes day and night as couple, and 360 such couples give the number 720. The *Taittiriya Saṃhitā* gives 360 *stotriyas* (verses) for recitation for 360 nights.[45]

5. Sidereal *(nākṣatra)* solar year of 366 days$=27 \times 13\frac{5}{9}$ days. The Sun was considered to remain in each *nakṣatra* $(13+\frac{1}{9}+\frac{2}{9})$ days $= 13\frac{5}{9}$ days. This refers to the revolution of the Sun with reference to a fixed star. The *Nidāna-sūtra*[46] gives a summary of all these year length.

The *Ṛgveda*[47] states that Varuṇa knew the 12 months and the animals created during that period as also the intercalary month which used to be created (near the 12 months). In the *Taittiriya Saṃhitā*[48] there is a passage which says that a day is omitted after some *ṣaḍahas* (six day week), and *māsas* are observed. It indicates the circumstances in which the day is omitted during the period. The lunar month is equivalent to $29\frac{1}{2}$ days, two such months are equivalent to 59 days. Therefore, if a *ṣaḍaha* ceremony is commenced on the first day of the lunar month, the second lunar month would end one day earlier. This shows that attempts for intercalation were made in Vedic times to adjust the lunar month or year agreeing with the civil year and the seasons. The *Ṛgveda*[49] points out that the year occasionally has a thirteenth or additional month which is produced of itself. Shamasastry[50] explains that a cycle of three *sāvana* years of 360 days each was followed by a year of 380 days. As a result the four-year period contained 1461 days, each average civil year being $365\frac{1}{4}$ days.

The natural means of measuring a year originated from the experience of periodic recurrence of climatic seasons. Likewise the natural means of measuring a day was the period between two consecutive sun-rises, and that for a month a period between two full-moons. The return of the Sun to the same position with respect to the fixed stars might have appeared to be much more reliable than the slow seasonal variation of the length of day light. There appears to be a constant attempt at adjusting the lunar months with the seasons. The idea of intercalating a month at regular intervals of time or of adding of 5 or 6 days in one month or more months was thus developed. Naturally, three units of time measurement, viz. the solar day, the lunar month, and the solar year are involved. Consequently, the luni-solar adjustment depended on the problem of finding the integers x, y, z, which satisfy the relation

$$x \text{ years} = y \text{ months} = z \text{ days}$$

This type of adjustment was attempted in late Vedic and the *Vedāṅga Jyotiṣa* period.

A bigger unit of time of five years known as *yuga* was also conceived for this adjustment. The *Taittiriya Brāhmaṇa*[51] states thates that five years, viz. *samvatsara, parivatsara, idāvatsara, iduvatsara* constituted the *yuga*. We find mention of two year names also in the *Ṛgveda*[52] and all names with little variations appear in the *Yajurveda*.[53] The conception of *caturyuga* and *kalpa* were possibly later developments,

LUNAR MONTHS, SEASONS AND SOLAR MONTHS

The Sun generates all the earthly directions and controls the seasons.[54] The *Taittiriya Saṃhitā*[55] gives the names of the following seasons and corresponding solar months.

Lunar months	*Seasons*	*Solar months*
Caitra	Vasanta (Spring)	Madhu
Vaiśākha		Mādhava
Jyeṣṭha		
	Grīṣma (Summer)	Śukra
Āṣāḍha		Śuci
Śrāvaṇa		
	Varṣā (Rains)	Nabha
Bhādrapadā		Nabhasya
Āśvina		
	Śarada (Autumn)	Iṣa
Kārttika		Urja
Margaśīrṣa (Agrahāyaṇa)		
	Haimanta (Dewy)	Saha
Pauṣa		Sahasya
Māgha		
	Śiśira (Winter)	Tapa
Phālguna		Tapasya

The lunar month used to be measured from full-moon to full-moon or from new-moon to new-moon as it is now; it was more widely known because of its association with festivals. More-over, it was easy to measure a lunar month, while the method of computating a solar month was not an easy task.

SOLSTICES (AYANAS) AND EQUINOXES

During the time of Mohenjo-daro, the new year began with the end of Kārttika *purṇimā*. This marked the equinoctial day, the day of yearly sacrifice, as well as beginning of year and of *yuga*. The *Kauṣitaki Brāhmaṇa*[56] reports that the Sun rests on the new-moon day of Māgha *(māghi-amāvasyā)* being about to turn towards north. On this day the *mahāvrata* rites were performed. This refers to winter solstice day. From the statement of the *Vedāṅga Jyotiṣa* that the solstices coincide with Āśleṣā *(māghi amāvasyā)* and Dhaniṣṭhā *(śrāvaṇa amāvasyā)*, the vernal equinox appears to have coincided with Bharaṇyaḥ *(kārttika amāvasyā)*. The system of new year definitely changed from *pūrṇimānta* to *amānta* system. This fact was observed though it does not follow from this that the Indians knew the phenomenon of precession. The shift from *kārttika pūrṇimā* to *kārttika-amāvasyā* is due to precession of equinoxes and is about 15 *tithis*, (1 *tithi* difference = 72 years, 15 *tithis* = 15 × 72 years = 1080 years).

From *māghi-amāvasyā* day the Sun goes towards north for six months, stands still and then turns towards south. On this day, when it was turning towards south, the rites of *vaiṣuvatīya* (summer solstice) are performed. Thus the year is divided into two halves of six months marked by winter solstice and summer solstice. The increase in day-lengths and corresponding decrease in lengths in night from winter solstice to summer solstice are noted in later texts, the longest day-length at summer solstice being 18 *muhūrtas* and the shortest day-length at winter solstice being 12 *muhūrtas*.

The *Taittiriya Saṃhitā*[57] also notes that the Sun moves northwards *(uttarāyaṇa)* for six months and southwards *(dakṣiṇāyana)* for six months. These progresses are referred to also in the *Ṛgveda*[58] and in the *Atharvaveda* as *Devayāna* and *Pitryāna*. The later astronomical texts mention these movements as *uttarāyaṇa* (northern movement) and *dakṣiṇāyana* (southern movement).