CHAPTER - 6

Some Astronomical Principles : An Indian Perspective

Two types of knowledge: *aparāvidyā* (inferior knowledge) and *parāvidyā* (superior or spiritual knowledge) have been accepted in Indian tradition. An act of worship done with a specific worldly desire was considered an inferior form of worship and was popular with the kings. *Aparāvidyā* enables man to attain material progress, enrichment and fulfilment of life and *parāvidyā* ensures attainment of self-realization or salvation in life (*Chānd. Up.* 7.1.7; *Muṇḍa. Up.* 1.2.4-5). The Vedic people, in general, made interesting synthesis by adopting *nitya* (perpetual or daily) and *kāmya* (optional for wish-fulfilment) sacrifices or offerings. The first was supposed to bring happiness to the family and second was for material progress. The perpetual daily sacred fires and the optional fires were placed on altars of various shapes. As to the reasons, which might have induced the ancient Indians to devise all these strange shapes, the *Ṛg-Veda* (1.15.12) says, 'He who desires heaven, may construct falcon shaped altar, for falcon is the best flyer among the birds'. These may appear to be superstitious fancies but led to important contributions in geometry and mathematics because of their conviction in social value systems.

To find the right time for religious, agricultural, new year and other social festivals gave the motivation for recording of recurrence of repeated events from seasons, stars, movement of planets, moon etc. This helped to develop many a framework for mapping of movements of heavenly bodies with reference to East, West, North and South points, *nakṣatras*, calendar, *yuga*, *mahāyuga* and movement of planets for mean and true positions of planets. Various mathematical and trigonometrical tables were also formulated for better and better results. The *Vedānga Jyotiṣa*[1] mentions as under:

Having saluted Time with bent head, as also Goddess Saraswati, I shall explain the lore of Time, as enunciated by sage Lagadha. As the crests on the head of the peacocks, the jewels on the serpents, so is the (*jyotiṣa gaṇitam*) held at the head of all lores among all *vedāṅga śāstras*.

Gaṇita is a variant reading for *jyotiṣa* meaning computation, which is the essence of this science.

Another tradition, which has enriched specialized activities in mathematics and astronomy is the *guru-śiṣya-paramparā* (teacher-student tradition). Different *recensions* of Vedic schools, *śulbakāras*, *jyotiṣkaras* (Varahāmihira names twenty scholar before him), Kusumpura school, schools of Ujjain and *Asmakadeśa*, and Jain and Buddhist schools are also well-known in this connection.

Beside these, there were commercial and other problems, which were tackled for *lokavyavahārārtha*, used for common people. The restriction and emphasis were also assured on social use and value systems, which helped people to take up different activities for commerce, education and other areas. These helped undoubtedly to concretise knowledge resulting in original contributions to mathematics and astronomy.

Construction of altars and nature of knowledge :

The ritual connection of Indian geometry, as elaborated by Thibaut and Burk, has been intensively discussed by Datta, Seidenberg, Sen and Bag, and others.[2] The ceremonies were performed on the top of altars built either in the sacrificer's house or on a nearby plot of ground. The altar is a specified raised area, generally made of bricks for keeping the fire. The fire altars were of two types. The perpetual fires (*nitya agni*) were constructed on a smaller area of one Sq. *puruṣa* and optional fires (*kāmya agni*) were constructed on a bigger area of 7½ sq. *puruṣas* or more, each having minimum of five layers of bricks. The perpetual fires had twenty-one bricks and optional fires had two hundred bricks in each layer in the first construction with other restrictions. For optional fire altars, the whole family of the organizer had to reside by the construction site of optional fire altar, for which another class of structure known as *mahāvedī* and other related *vedīs* were made. However, a summary of these types of altars with ground shapes are grouped below:

(a) Perpetual fire altars (area coverage: 1 sq. *puruṣa*): *āhavanīya* (square), *gārhapatya* (circle or square), *dakṣiṇāgni* (semicircle).

(b) Optional fire altars (area coverage: 7-½ square *puruṣa*): *Caturasraśyenacit* (hawk bird with square body, sq uare wings, square tail), *kankacit* and *alajacit* (bird with curbed wings and tail), *prauga* (triangle), *ubhayata prauga* (rhombus), *rathacakracit* (circle), *draṇacit* (trough), *śmaśānacit*, (isosceles trapezium), *kūrmacit* (tortoise) etc.

(c) Vedis: *mahāvedī* or *saumikī vedī* (isosceles trapezium), *sautrāmani vedī* (isosceles trapezium, and also one-third of the *mahāvedī*), *paitṛkī vedī* (isosceles trapezium or a square, area one-third of *sautrāmani vedī*), *prāgvaṃśa* (rectangle).

One can guess the nature of knowledge, which could originate from such altar constructions. However, the *Śulba-Sūtras* of Baudhāyana, Āpastamba and other schools have summarized this knowledge as available from the Saṃhitas and Brāhmaṇas. Both Baudhāyana and Āpastamba belonged to different schools but followed a similar pattern, which also suggests that these schools inherited the knowledge from older schools. While giving details, the *Śulba-Sūtras* use the word *vijñāyate* (known as per traditions), *vedervijñāyate* (known as per Vedic tradition) etc. very often. A summary of this knowledge will be of great interest.

Baudhāyana gives various units of linear measurements viz., 1 *pradeśa* = 12 *angulas*; 1 *pada* = 15 *ang*; *iṣa* = 188 ang; 1 *akṣa* = 104 ang; 1yuga = 86 ang; 1 *janu* = 32 ang; 1 *śamyā* = 36 ang; 1 *bāhu* = 36 ang; 1 *prakarma* = 2 *padas*; 1 *aratni* = 2 *prādeśas*; 1 *puruṣa* = 5 *aratnis*; 1 *vyāyama* = 4 *aratnis*; 1 ang = 34 *tilas* = ¾ inch (approx.).

Knowledge of rational numbers like 1, 2, 3 ... 10, 11 ... 100 ... 1000, ½, ⅓, ¼, ⅛, 1/16, 3/2, 5/12, 7½, 8½, 9½ etc. were used in decimal word notations and their fundamental operations like addition, subtraction, multiplication and division were carried without any mistake.

Baudhāyana had knowledge of square, rectangle, triangle, circle, isosceles, trapezium and various other diagrams and transformation of one figure into another and *vice-versa*. Methods of construction of square by adding two squares or subtracting two squares were known. The areas of these figures were also calculated correctly. That the length, breadth and diagonal of a right triangle maintain a unique relationship, $a^2 + b^2 = c^2$ (where a = length, b = breadth and c = hypotenuse) or in other words (1, 1, 2) (2, 1, 3) formed important triplets thereby forming an important basis for number line, and were used for construction of bricks and geometrical figures. For easy verification, Śulbakaras suggested triplets expressed in rational and irrational numbers like (3, 4, 5), (12, 5, 13), (15, 8, 17), (7, 24, 25), (12, 35, 37), (15, 36, 39), (1, 3, $\sqrt{10}$), (2, 6, $\sqrt{40}$), (1, $\sqrt{10}$ $\sqrt{11}$), (188, 78⅓, 203⅔), (6, 2½, 6½), (10, 41/6, 105/6) and so on. A general statement on 'Theorem of Square on Diagonal' was also enunciated thus: 'The areas (of the squares) produced separately by the length and the breadth of a rectangle together equals the area (of the square) produced by the same diagonal'. This has been wrongly referred to Pythagoras who was associated with the triplet (3, 4, 5) and the theorem is known as the Pythagorian theorem. Indian knowledge is based on rational and irrational arithmetical facts and geometrical knowledge of transformation of area from one type to the other and its importance was perhaps correctly and perfectly realised. How the Babylonians, Egyptians, Chinese and the Greeks came upon the knowledge of triplets but not the general statement is equally important for an interesting study.[3]

The *Śulba-Sūtra* tradition vanished. Only a limited commentary from a late period is available. Whether the tradition has been lost or the elements have been absorbed in temple architecture is still to be investigated and may be the part of other studies.

Decimal scale, decimal place-value, numerical symbols and zero :

'Our numerals and the use of zero', observes Sarton[4] (1955), 'were invented by the Hindus and transmitted to us by the Arabs (hence the name Arabic numerals which we gave them)'. The study of Sachs, Neugebauer on Babylonian tablets, Kaya and Carra de Vaux on Greek sciences, Needham on Chinese sciences and study of Mayan culture have many interesting issues. The study of scholars likes Smith and Karpinski, Datta, Bag and Mukherjee[5] have analysed Indian contributions, but still there is a need for a comprehensive volume. However, the salient points may be of interest: The Indians had three-tier system of word-numerals starting from the Samhitās as follows:

(a) *Eka* (1), *dvi* (2), *tṛ* (3), *catur* (4), *pañca* (5), *ṣaṭ* (6), *sapta*(7), *aṣṭa* (8),and *nava* (9).

(b) *Daśa* (10), *vimśati* (2 x 10), *trimśat* (3 x 10), *catvārimśat* (4 x 10), *pañcāśat* (5 x 10), *ṣaṣṭhī* (6 x 10), *saptati* (7 x 10), *aśiti* (8 x 10) and *navati* (9 x 10).

(c) *Eka* (1), *daśa* (10), *śata* (10^2), *sahasra* (10^3), *ayuta* (10^4), *niyuta* (10^5), *prayuta* (10^6), *arbuda* (10^7), *nyarbuda* (10^8), *samudra* (10^9), *Madhya* (10^{10}), *anta* (10^{11}) and *parārdha* (10^{12}).

The names and their order have been agreed upon by almost all the authorities for (a) and (b), whereas there is a variation in (c) where mostly one or two terms have been added later. The numbers below 100 were expressed with the help of (a) and (b) sometimes following additive or substractive principles e.g., *trayodaśa* (3 + 10 = 13), *unavimśati* (20 – 1 = 19), while for numbers above hundred, groups (a), (b) and (c) were used. For example, *sapta śatāni vimsati* = (720), *ṣaṣthim śahasrā navatim nava* = (60, 099).

One feature of the application of the scale is that it has been used in higher to lower order (*sahasra, śata, daśa* and lastly the *eka*). Real problem started when the numerical symbols began to appear. The *aṣṭakarṇī* or *aṣṭamṛdam* fairly indicates that Vedic people identified eight marks but whether they identified other symbols is not known. The

Mahābhārata (III. 132-134) narrates a story in which it says that 'The signs of calculation are always only nine in number[2]. The *aṣṭādhāyī* of *Pāṇini* (450 BC) used the word *lopa*, and Patañjali the word *śunya* in connection to metrical calculations. When Brāhmī and Kharoṣṭhi numerals/alphabets appeared on the scene, there were lot of confusions creating more problems for ordinary business people and the mathematicians and astronomers as to how to use the numerical symbols and adjust with the existing decimal system. The early inscriptions show the number system was additive and did not use decimal scale. Moreover numerical symbols were many in the beginning and it was difficult to decipher the correct meaning.

First attempt of a synthesis of the Vedic decimal system with the prevalent situation was possibly made by the Jains. The *Anuyogadvārsūtra* (100 BC) has described the numerals as *anka* as we find in Bengali to mean mathematics and describes decimal scale as decimal places (*gaṇanāsthāna*) and their numeral vocabulary was analogous to, that of the Brahmanic literature. They have enlarged these places to 29 and beyond, and we find more clear statement in mathematics cum astronomical texts from *Āryabhaṭṭa* onwards in expressions like *sthānāsthānam daśaguṇam syāt* (from one place to next it should be ten times) and *daśaguṇottarāḥ samjñāḥ* (the next one is ten times the previous one). This indicates that the scale was merged with the places, and the system became very simple. For example, the Vedic numbers:

sapta śatāni vimśati and *ṣaṣṭhim sahasrā navatim nava* reduces to:

sahasra (10^3),	*śata* (10^2),	*daśa* (10),	*eka* (1)	Places
	7	2	0	= 720
60	0	9	9	= 60,099

The order of the Vedic scale was from higher to lower (*sahasra, śata, daṣa* and *eka*). But later, the order of the scale was changed from left to right i.e., *eka, daśa, śata* etc. This is obvious when we think that in the Vedic system all words were spoken, and in the latter system the scale obviously followed the written style (that is from left to right) and the place values were from *eka* to higher order. Moreover, the symbols were not standardized and interpreted differently in different regions. To avoid this problem, experts coined synonymous words and used them as symbols in decimal place-value in lower to higher order and the actual number was obtained by reversing the number. For example: *śunya* (0), *dvi* (2), *pañca* (5), *yama* (2) was actually 2520.

The Kashmiri *Atharva-Veda* also uses similar symbols.

Association of decimal scale with place-value was so popular in Indian tradition that it was not even commented upon. The popularity went to deep that even Śankaracārya (c. AD 800), the great social reformer, pointed out that the same numerical sign if placed in unit, tenth, and hundredth places becomes 1, 10, 100. The men in business or in elementary schools (*pāthśalā*) used wooden board (*pāṭī*), hence the name *pāṭīgaṇita*, for quick calculation, in which dust was spread and finger or hard materials were used for calculation. The system also moved to Java, Malaya, and other East. Indian colonies along with the business people, which is evidenced from some available inscriptions. The use of decimal place-value in lower order with word-numerals and higher to lower order with numerical symbols was in practice. For calculation on a *pāṭī*, numerical symbols were used, but for writing or copying a manuscript, final results were written in word numerals to avoid confusion in decoding a symbol and also to keep rhythm in verses in which it was written. The zero in many places of *Bakshālī. Ms* (AD 400) has been used as a round symbol (*śunya*, 0). It also came out as dot (·), may be, that thick tip of pen used for circle became dot in the process. This is distinctly visible in *Bakshālī Ms* and the Kashmiri *Atharva-Veda.* Alberuni (c. 1020 AD) has incidentally referred to two systems of notation of numbers, namely alphabetic (*abjd*) system (*Huruf al-jummal* or *HiSab al-jummal*) and the Indian numerals (*al-Arqam al-Hind*). He has recorded Indian numerals of nine symbols, and zero as dot in the *Kitab al-Tafhim* (the book of instruction in the art of astrology). He also referred to circular symbol (O) of the Indian. *Al-Khwārizmiī* (825 AD), another Central Asian scholar, writes about Indian numerals[6] thus, 'The beginning of the order is on the right side of this writer, and this will be the first of them consisting of unity. If instead of unity they wrote X, it stood in the second digit and their figure was that of unity, they needed a figure of ten similar to the figure of unity so that it became known that this was X, and they put before it one digit and wrote it in a small cicle "0" so that it would indicate that the place of unity is vacant.' The Indian name *śunya* was taken over by the Arabs as *aṣ-ṣifr*. This was subsequently changed to *zephirum* (1202, Fibonacci), *tziphra* (1340, Planudes) and *Zenero*, *zepiro* (sixteenth century, Italy).

Astronomical Features :

The fire sacrifices including construction of fire altars appearing in the *Saṃhitās*, *Brāhmaṇas* and the *Śrauta-Sūtras* clearly indicate that *agnihotṛs* were concerned mainly with directions for laying the sacrificial fires, new and full moon, the season and accurate calculation of the times of the year etc. The fixation of east-west and north-south lines was considered very important for the construction of altars. *Kātyāyana* says′ that eastern and western shadow-points of a central pole in a circle on equinoctial day fix the east-west line and the line perpendicular to that gives the north-south line. The *Śatapatha-Brāhmaṇa* reports the *Kṛttikā* never deviated from the east. R.N. Apte, the well-known Vedic scholar feels that east point was verified by the rising point of *Kṛttikā* in the Vedic period. The Vedic people took Sun as the sole light-giver of the universe, the cause of the seasons, winds, controller and the lord of the world. The Moon was described as *sūryaraśmi*, one which shines by the sun's light. Different phases of the moon viz., *rākā* (full-moon day), *anumati* (preceding full-moon day), *kuhu* (next full-moon day), *śinivāli* (preceding new-moon day) etc. was known. The *Taittirīya-Brāhmaṇa* gives a full list of name of 15 days of the light half (*pūrva pakṣa*) and also of dark half (*aparapakṣa*). The day was called *vāsava* or *aha* and reckoned from sunrise to sunset. The day was further divided into different parts. The period from one moonrise to the next or from one moonset to the next was known as *tithi*, which is somewhat different from the present concept of *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 by its being released by the Sun.

Nakṣatras, Months, Names of Seasons and New Year :

The *nakṣatras* or the group of stars near which the moon could be seen are the conventional division or marker of the ecliptic, (the path) which is followed by Moon, Sun and the Planets. The Moon returns to the same position in more than 27 days but less than 28 days. There is mention of 28 *nakṣatras* early *saṃhitās*, *Atharva-Veda* and others, but the numbers were reduced to 27 from the time of *Vedānga Jyotiṣa*. The names of these *nakṣatras* with their presiding deities are enumerated in the *Yajur-Veda* beginning with *Kṛttikā*. The lunar (or synodic month) was measured from full-moon to full-moon or from new-moon to new-moon (*TS.* 7.5.6). The *Taitt*, *saṃhitā* (5.6.7) refers to 12 or 13 lunar months of a year and calls the 13th (intercalary) month by the names *Saṃsarpa* and *Aṃhaspati* (*TS.* 1.4.14). The *six ṛtus* in solar year with names of 12 tropical months are in *Taitt. Sam*, (4.4.11.1) and *Vājasaneyī saṃ* (13.14). Studies have already been made on *Rohiṇi*, *Kṛttikā*, *Bharaṇī* and *Aśvinī* legends by Tilak, Shamaśāstry, Sengupta, Dikshit, Kupannaswamy Śāstry which indicate that the reference point on the ecliptic on equinoxial day (when day and night were equal) shifted to asterism *Rohiṇi*, *Kṛttikā* (Saṃhitā period), *Bharaṇī* (*Vedānga Jyotiṣa* period), *aśvinī* (*Sūrya Siddhānta* period) in course of time. A seal from the Mohenjo-daro (*M.* 2430) corroborates the *Kṛttikā* legend[7] which supports that the new year started from *Agrahāyanī* after the full moon at *Kṛttikā*. By the time of *Kauśitakī-Brāhmaṇa* (19.8) the new year started with the winter solstice (shortest day) and it was on the new moon day of Māgha. This indicates that the purnimānta system (from the termination of full moon) changed to amānta system (from the termination of new moon) with time and the effort went on to synchronize lunar month with the beginning of the tropical year and seasons.

Nakṣatras Taitt-Saṃ 4.4.10 Athar. Ved. 19.10		Lunar Months	Solar Months & Seasons Taitt-saṃ 4.4.11 Vāj. Saṃ 13.14	
1.	*Kṛttikā* (Alcyon, 360 long)	Kārtika	Urja	Śārada (Autumn)
2.	Rohini (Aldebaran, 460)			
3.	Mṛgaśirsa (λ Orionis, 600)	Agrahāyanī	Saha	Haimanta (Dewy)
4.	Ārdrā (Betelguese, 650)			
5.	Punarvasu (Pollux, 900)			
6.	Puṣyā (Cancrii, 1050)	Pauṣa	Sahasya	
7.	Āśleṣa (Hydras, 1090)			
8.	Maghās (Regulas, 1260)	Māgha	Tapa	Śiśira (Winter)
9.	(Pūrva) Phalguni (δ Leonis, 1380)	Phalguni Tapasya		
10.	(Uttara) Phalguni (Denebola, 1480)			
11.	Hastā (δ Corvi, 1700)			
12.	Citrā (Spica, 1800)	Caitra	Madhu	Vasanta Spring
13.	Svātī (Arcturus, 1810)			
14.	Viśākhe (Centauri, 2160)	Vaiśakha Mādhava		
15.	Anurādhās (Scorpi, 2190)			
16.	Jyeṣṭhā (Antares, 2260)	Jaiṣṭha	Śukra	Grīṣma (Summer)
17.	Mūlā (λ Scorpi, 2410)			
18.	(Pūrva) Āṣādhās Sagittarii, 2510)	Āṣāḍa	Śuci	
19.	(Uttara) Āṣādhās Sagittarii, 2590)			
20.	Abhījit (Vega, 2620)			
21.	Śravanā (Altair, 2780)	Śrāvaṇa	Nabha	Varṣā (Rainy)
22.	Śraviṣṭhās (β Delphini, 2930)			
23.	Satabhisā (λ Aquarii, 3180)			
24.	(Pūrva) Proṣṭhapadās (Markob, 3300)	Bhadrapadā	Nabhasya	
25.	(Uttara) Proṣṭhapadās (√ Pegasi, 3460)			
26.	Revatī (ℓh Piscium, 3560)			
27.	Aśvaujau (β Arietis, 100)	Aśvina	Isa	Śārada (Autumn)
28.	Bharaṇīs (41Arietis, 250)			

Luni-solar adjustments and time units :

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 full moons. The return of the Sun to the same position with respect to the fixed star 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 month with the season. The *Taittirīya-Saṃhitā* (7.2.6) mentions how eleven days ceremony (*ekādaśarātra*) were performed after lunar year of 354 days to make up with the seasons (*ṛtus*) i.e., with the sidereal year of 365.25 days. The idea of intercalating a month at regular intervals of time or of adding of five or six 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 adjustments depended on the problem of finding the integers x, y, z which satisfy the relation, x years = y months = z days. The *Ṛg-Veda* gives two years (*samvatsara, parivatsara*), *Taittirīya-Brāhmaṇ* (1.4.10) mentions four years (*samvatsara, parivatsara, idavatsara* and *ānuvatsara*). Shamśāstry also believed in a four year cycle, first three years of 360 days and fourth year = 146¼ = 365¼ days. The *Vedanga Jyotiṣa* gives (both *Ṛgvedic* recension – *ārca jyotiṣa*, 36 verses and *Yajurvedic* recension - *yājuṣa jyotiṣa*, 43 verses) a five-year cycle, the number of sunrising, moon rising, *tithi*, *nakṣatra*, the new-moon, full-moon, account for solstices, seasons, Sun's northward and southward journey, increase and decrease of day lengths during these journeys, rules for determining the beginning of the season, etc. It prescribes five solar years = 62 sidereal months (moon's revolution) = 67 lunar months (synodic) months. In this cycle of five years, solar days = 5x12x30 = 1800, civil days (solar rising_ = 1830, sidereal days (solar rising plus solar cycle, earth's rotation) = 1835. A five year was conceived as *yuga* in *Vedānga Jyotiṣa*. The conception of *caturyuga*, and *kalpa* were later developments. The *Vedānga Jyotiṣa* (*Y-VJ*, 24) also gives time units (measured by water clock), 1 *āḍikā* = 50 *palas*, 1 *kuḍava* = 1/16 *āḍikā* = 3⅛ *palas*, 1 *nāḍikā* = 200 palas – 3/16 *āḍakas* = 4 *āḍakas*-3/16 *āḍakas* = 6 1/16 *āḍakas* = 61 *kuḍavas*, 1 *nāḍika* = 10 1/20 *kalās*, 60 *nāḍikās* = *muhūrtas* = 1 day.[8]

Astrological tradition :

The *Atharva Jyotiṣa* (in 14 chapters, 162 verses) attached to *Atharva Veda* tradition deals with the *muhūrta* branch of astrology. *Atharva Veda* says that it was taught by Pitāmaha to Kaśyapa. The *muhūrta* as a time unit comes first in the *Śatapatha Brāhmaṇa* (12.3.2.5) which gives 1 *divasa* = 30 *muhūrtas*, 1 *muhūrtas* = 15 *kṣipra*, 1 *kṣpra* = 15 *itarhis*, 1 *itarhi* = 15 *idānis*, 1 *idāni* = 15 *prāṇas*. The *Atharva Jyotiṣa* gives the unit as *ahorātra* (whole day), *muhūrta*, *truṭi*, *kalā*, *lava*, former being 30 times the next instead of 15 times. The last unit is *nimeśa* (1 *lava* = 12 *nimeśa*). Reference to 7 planets, sun, moon and five planets are found. The *Atharva-Veda* (19.9) writes, 'May the Gandramāsa and Āditya *graha* along with Rāhu prove auspicious to you'. The *Atharva Jyotiṣa* also gives names of seven week days with names of planets and describing planets as 'Lord of the days'. The names are *āditya* (sun), *śoma* (moon), *bhauma* (mars), *budha* (mercury), *bṛhaspati* (Jupiter), *bhārgava* (Venus) and *śani* (Saturn). In other places it has also used names of planets as being applicable to planets like *Sūrya* (Sun), *Lohitānga* (Moon), *Śomasuta* (Mercury), *Devaguru* (Jupiter), *Bhṛgu*, *Śukra* (Venus), *Muryasuta* (Saturn). This also contains the seeds of prediction of *Jātaka* astrology expressing fears, woes and horrors when certain *nakṣatras* are accompanied by planets, meteors (*ulkā*) etc. The *Aśvālayana Sutra* contains instructions like fields should be ploughed on the *uttara proṣṭhapāda*', (*Gṛhya-Sūtra*, 2.10.3), 'thread ceremony should be performed on auspicious *nakṣatras*' (*Gṛhya-Sūtra*, 1.4.1) etc. The words, *muhūrta* and *kṣana* also appear in the '*nirukta*'. The *Yājñavalka Smṛti* gives the names of nine planets (seven planets, *Rāhu* and *Ketu* (*Ācāradhyāya*) and twelve parts of the ecliptic (*rāśis*) in order to find proper times (*Śūrya-saṃkarama*) for performing the *śrādha*. The *Yavana Jātaka* of Sphujidhvaja[9] (AD 269) is considered as a major work carrying Greek influence. But it has also used (last chapter) time units viz. *palas*, *kuḍavas*, *liptās*, *nāḍikā*, *kāla*, *muhūrta*, (or *kṣaṇa*) same as *Vedānga Jyotiṣa*, with the exception that it has used 1 *nāḍikā* = 10 *kālas* instead of 10 1/20 *kālas* used by *Vedānga Jyotiṣa*, possibly to avoid fraction. It has conceived a cycle of 165 years instead of 5 years and has given the number of solar months, solar days, civil days, intercalary months, *tithes*, omitted *tithes*, sidereal months and other elements for this cycle. The *Bṛhajjātaka* (or *Bṛhat Jātaka*) is the next most important work on astrology by Varāhamihira (c. AD 505) who also compared *Bṛhat Jātaka* (horoscopic work) and three smaller works on marriage and *yātrā* (journey) on astrology, besides collection of five important works on astronomy (*Pañcasiddhāntikā*). Varāhamihira referred to Parāsara (twice, *Māṇḍavya* and *ācaryas* like *Satya*, *Maya*, *Yarana*, *Manithya*, *Jivasarma*, *Viṣṇugupta* (identified as Cāṇakya *Viṣṇugupta*, the minister of Candragupta by the commentator). *Bhaṭṭotpala* (c. AD 966), the commentator on the *Bṛhat Jātaka* has given astrological quotations from the works of *Gārgī*, *Badarāyana*, Yājñavalkya and Māṇḍyavya. The *Bṛhat Jātaka* contains 36 Greek words namely, the 12 signs – *kriyā*, *taburi*, *jituma*, *kulir*, *leya*, *pāthena*, *jūka*, *kaurpya*, *tauksika*, *akokera*, *Hridroga*, *Ittham* and twenty four other words including the words, *liptā*, *horā*, *dreskāna*, *Kendra*, *koṇa* etc. On the basis of these terms, Weber and Kern believe that there was Greek influence on Indian astrological works. Large number of late astrological works on *jātakas* (*Kālacakra-Jātaka*, *Gauri-Jātaka*, *Mīnarāja-Jātaka*, *Jātakasāra* of Nṛhari, Sārāvalī-*Jataka Paddhati* etc.) dealing with misery and woe based on ascendants and descendents of planets, *horās* (by Vaśiṣṭha, Garga, Parāśara, Varāha, Lalla, Nārada etc.) dealing with whether an event will happen at all, if so, when and how on the basis of horoscope cast, *muhūrtas* (*tithes*, *nakṣatras* prohibited for auspicious ceremony, taboos etc.), *pāśaka vidyā* (questions answered according to the casting of dice), *tājik* (forecasting as per ascendance and descendence of planets) etc. were in vogue.

Yuga, Kalpa and Mahāyuga :

The *Vedāṇga Jyotiṣa* had a cycle of five years in a *yuga*. The *Yavana Jātaka* had 165 years cycle. The *Pāṇini*, though refers to *yuga* and *kali*, it is *Manusmṛti* which gives four *yugas* (*Kṛta*, *Tretā*, *Dvāpara* and *Kali*) = 12000 divine years = 4320000 ordinary human years, since 1 Divine year = 360 ordinary years. The *Mahābhārata* also had the same *yuga* and time units as that of *Manusmṛti*. The Siddhāntic astronomy, unlike Greek astronomy, has established on epoch when all planets were in zero longitude. Āryabhaṭṭa I considered on epoch when the Sun, the Moon, Mars, Mercury, Jupiter, Venus and Saturn were last in zero longitude at sunrise in Lankā (a hypothetical place at the intersection of the equator and the meridian of Ujjain) on Feb. 18, Friday, 3102 BC. The period of one such epoch to the next, according to Āryabhaṭṭa I is 1,080,000 years. When the Moon's apogee and the Moon's ascending node are included in the list of the planets, the above mentioned period (*mahāyuga*) becomes 4,320,000 years, which is defined as the duration of *yuga*. The *yuga* is a period of time which begins and ends when the Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn, the Moon's apogee and the moon's ascending node are in zero longitude. It consists of 4 periods, *Kṛta*, *tretā*, *dvāpara* and *kali*, the current quarter *yuga* is the current *kaliyuga* which is assumed to have begun at sunrise at Lankā on Friday, 18 Feb., 3102 BC. A bigger period than the *yuga* is called *kalpa*. According to Āryabhaṭṭa I, *kalpa* consists of 1008 *yugas*, and 459¾ *yugas* had elapsed at the beginning of current *kaliyuga* since the beginning of current *kalpa*. The main difference in Āryabhaṭṭa, Sūrya-Siddhānta and Brahmana Siddhānta School is that the length of the year and motion of planets in a *kalpa* and *mahāyuga* is different and other elements are same. There is also difference of opinion as to the starting of *kali* era on 18 Feb., Friday, 3102 BC, which needs more careful scrutiny. The Hindu astronomical works called *Siddhānta* adopt the terms of creation as the epoch of calculation whereas those called *kaliyuga* as the epoch of calculation.

Old Siddhāntic Tradition :

The Jains did positive contributions to mathematics. A few works like *Surya Prajñnapti, Candra Prajñapti, Jamboo Divīpa Prajñapati, Sthānānga Sūtra, Bhagavatī Sūtra, Anuyogadvāra Sūtra* are available to us. It deals with problems dealing with circle, chord, circumference, p (=10), diameter, arc, segment, big numbers, infinity, laws of indices, symbols, operations etc. Varāhamihira was born in AD 505 in the village of Kapithaka (Farrukabad district of Uttar Pradesh) and moved to Ujjain. His forefathers migrated to India from Maga country in Persia and settled in the Kapithaka. He quoted Āryabhaṭṭa I several times and compiled *Pañcasiddhāntikā* i.e., five siddhānta works, namely, *auliśa*, *romaka*, *vaśiṣṭha*, *saura* and *paitāmaha* besides astrological works. Colebrooke (1807-17), Whitney and Burgess (1860), Kern (1865), Thibaut (1890) and a few other European scholars passed judgement on the relative importance and origin of Indian astronomy. Thibaut in his introduction to the *Pañcasiddhāntikā* observes that the *Paitāmaha Siddhānta* (c. AD 80) is the oldest and carries pre-scientific stage of astronomical knowledge. The *Vaśiṣṭha Siddhānta,* written prior to AD 269 is more advanced. The *Romaka* and *Pauliśa* have Greek influence. The *Saura Siddhānta* only contains new features. During the early centuries of the Christian era the Indians were in touch with the Greeks, Romans and other scholars and those of Babylonian and Greek knowledge may have been available to them.

The scholars like Dikshit, Sengupta, Ganguly, Kuppannaswamy and Shukla[11] testified that the refinements introduced by Ptolemy (AD 150) and even Hipparchus (150 BC) remained unknown to India. Whatever Greek influences are there, they are all of pre-Ptolemaic period and possibly of pre-Hypparchus time. The extent and nature of contact were through conferences or direct borrowal through translation of texts is still to be investigated. Neugebaur has shown that the *Vaśiṣṭha* and *Pauliśa* were inspired by Babylonian linear astronomy.

The *Pañcasiddāntikā* (five *siddhāntas*) were known in India from first century AD to fifth century AD. By this time, the Indians had already acquired the knowledge of zero and decimal place-value, eight fundamental operations of arithmetic addition, subtraction, multiplication, division etc., rule of three, inverse rule of three, knowledge of combinations of six savours (a, b, c, d, e, f), 2 at a time, c (6,4) – ab, ac, ad, ae, af, bc, bd, be bf, cd, ce, cf, de, df, ef – fifteen in all), 3 at a time c (6,3), 4 at a time c (6,4) was known. Likewise, the knowledge of binomial expansion for calculating the shortcomings in metrical rhythm of music based on *long* (a) and short (b) sounds were known. Or in other words binomial expansion like $(a + b)^2 = 1.a^2 + 2a.b + 1.\ b^2$, $(a + b)^3 = 1.a^3 + 3.a^2b + 3.ab^2 + 1.b^3$, $(a + b)^4 = 1.a^4 + 4.a^3b + 6\ a^2b^2 + 4ab^3 + 1.b^4$ and achieved various other mathematical results. These undoubtedly brought great change in the Indian scenario in the field of mathematics and astronomy. The development of algebraic and trigonometric tools also revolutionized the calculations and methods in astronomy.[10] A series of writings came in with Āryabhaṭṭa II Āryapakṣa school, Lāṭadeva, the student of Āryabhaṭṭa I and author of revised (*Sūryasiddhānta Sūryapakṣa* school), Brahmagupta (Brahmapakṣa school), Bhāskara I (AD 628), student of Āryabhaṭṭa School and a host of other scholars namely Lalla (c. AD 749), Vaṭeśvara (AD 904), Āryabhaṭṭa II (AD 950), Śrīpati (AD 1039), Bhāskara II (AD 1150) and others. Āryabhaṭṭa I, an *āsmakīya* (Keralian) lived in Magadha (modern Bihar) and wrote his *Āryabhaṭṭa*. Magadha in ancient time was a great centre of learning and is well-known for the famous university at Nalanda (situated in the modern district of Patna). There was a special provision for study of astronomy in this university. Āryabhaṭṭa I is referred to as *kulapa* (= *kulapati* or Head of a University) by the commentator.

Āryaṣiddhānta and Āryabhaṭīya of Āryabhaṭai (b, ad 496) :

The *Āryasiddhānta* of Āryabhaṭṭa is only known from the quotations of Varāhmihira (AD 505), Bhāskara I (AD 600) and Brahmagupta (AD 628) in which the day begins at midnight at Lankā. The *Āryabhaṭṭa* begins the day with sun-rise on Sunday *caitra-kṛṣṇādi*, *Śaka* 421 (AD 499). A summary of contents of *Āryabhaṭṭa* will give an idea how the knowledge exploded. Under arithmetic, it discusses alphabetic system of notation and place-value including fundamental operations like squaring, square root, cubing and cube root of numbers. The geometrical problems deal with area of triangle, circle, trapezium, plane figures, volumes of right pyramid, sphere, properties of similar triangle, inscribed triangles and rectangles. Theorem of square on the diagonal, application of the properties of similar triangles. The algebra has concentrated in finding the sum of natural numbers (series method), square of n-natural numbers, cubes of n-natural numbers, formation of equation, use of rule of three for application (both direct and inverse rule), solution of quadratic equation, solution of indeterminate equation [by = ax + c, X = (by – c) / a] where solution of x and y were obtained by repeated division (*kuṭṭaka kuṭ* means to pulverize) etc. In trigonometry, *jyā* (R Sine) is defined, and 28 *jyā* table at an interval of 3^0 45' (R = 3438') was constructed, the value of $\pi = 3.1416$ was found to be the correct to 34 places of decimals. Āryabhaṭṭa I's value of p = 62832 / 20000 = 3 + 1/7 + 1/17 + 1/11. Successive convergents are 3, 22/7, 355/113, 3927/1250 which were used by later astronomers. In astronomy, three important hypothesis were made viz.,

(1) The mean planets revolve in geocentric circular orbits,
(2) The true planets move in epicycles or in eccentric,
(3) All planets have equal linear motion in their respective orbits.

The knowledge of indeterminate equations played a significant role. The method of indeterminate equation was a successive method of division. The same method is possibly used for value of, solution of first degree and second-degree indeterminate equation. It was also used to determine the mean longitude of plane for mean longitude = (R x A)/C, where R = revolution number of planets, A = *ahargaṇa* = no. of days since the epoch and C = no. of days in a *yuga* or *kalpa*. Large number of astronomical problems of Bhāskara I are changed to $(ax - c)/b = y$ where x = *ahargaṇa* any y = Sun's mean longitude.

Astronomical corrections and astronomical instruments :

The geocentric longitude of a planet is derived by the mean longitude by the following corrections.

(1) Correction for local longitude (*deśāntara* correction).
(2) Equation of the centre (*bāhuphala*).
(3) Correction of the equation of time due to eccentricity of the ecliptic.
(4) Correction of local latitude (*cara*) in case of sun and moon, and an additional correction (*śighraphala*) in case of other planets.

Besides these, Vaṭeśvara (904) gave lunar correction, which gives deficit of the moon's equation of centre and evection. Bhāskara II (1150) gave another correction, variation.

Mañjulā (932) used a process of differentiation in finding the velocity of planet. All siddhāntic astronomy gave method and time of eclipse, along with *tithi*, *nakṣatra*, *kāraṇa*, *yuga*, since these had an important bearing on religious observations.

A large number of astronomical instruments were referred to and used. To cite a few from Lalla's *Śiṣyadhivṛddhida*[11] (eighth – eleventh centuries), these are (1) air and water instrument, (2) *golayantra*, (3) man with a rosary of beads, (4) self-rotating wheel, and self-rotating spheres, (*cakra yantra* circle), (6) *dhanur yantra* (semi-circle), (7) *kartari yantra*, the scissors, (8) *kapāla yantra* (set horizontally on the ground and its needle vertical), (9) *bhagaṇa yantra*, (10) *ghaṭī yantra* and conversion of observed *ghaṭīs* into time only, (11) *śanku yantra*, (12) *śalākā yantra*, needle, (13) *śakaṭa yantra* (for *tithi* observation), (14) *yaṣṭhī yantra* and graduated tube (for altitude, zenith distance and *bāhu*) and others.

The extension of knowledge by Kerala astronomers :

The knowledge of *jyā* (or *jiva*), *kojyā* and *śara* for a planet in a circle of known radius (*trijyā*) was used. The scholars used gradually improved value of (*trijyā*) where Sinus totus = 24^{th} *jyā* = R = 3438' (Āryabhaṭṭa I), 120' (*Pañcasiddhānta*), 3270' (Brahmagupta), 3437'44"19" (Govindasvāmī, AD 850), 3437'44"48"' (Mādhava c. AD 1400). From the relation $C = 2\pi R$, where C = circumference and R = radius of the circle, R was calculated. The value of C was taken as C = 360 degrees = 21600 minutes and $\pi = 3.1416$ (Āryabhaṭṭa I). Mādhava (c. AD 1400) used a value of π correct to 11 places of decimals. Mādhava used knowledge of series to approximate the value of *jīva* $= s = s^3 / 3lr^2$, and *śara* $= s^2/2lr$ for an arc s of radius r and applied them repeatedly.

Important trigonometrical relations were also found by scholars from Āryabhaṭṭa I onwards. The successive approximation[12] of Mādhava and other Kerala astronomers lead, for $s = rx$, to the discovery of

$$\sin x = x - x^3/3! + x^5/5! -- \ldots$$
$$\cos x = 1 - x^2/2! + x^4/4! -- \ldots$$

These were investigated and rediscovered later in Europe.

For the study of history it is important to find out the date or at least a period of any incident in the history of any country. This aspect of fixing the dates of Indian history came to importance when European scholars began their studies of Indian history. The European scholars had no concept of measurement of time with the help of astronomy. They used to count the days and years from a particular king or event. Such records are not present in the ancient history of India. Therefore nobody was able to fix the dates of the ancient Indian history.

It made clear that the Indian authors have given details of time by the astronomical records and by proper studies we can easily fix the dates of various incidents in the ancient Indian history accurately.

We think that the modern scientific calendar is very good because it is easy but it is not good. If a calendar from our wall is lost we are unable to find the date and month. If we happen to go to some isolated island after wrecking our ship then in four to five days we will forget the date and month and then will never be recalled. But a man like me who has studied the Indian calendar can easily tell *Tithi*, *Nakṣatra*, *Pakṣa*, Lunar months by looking at the night sky. By looking at the rising sun *Ṛtu* and *Ayana* can be told. Counting of the days can be done by *Tithi* and *Nakṣatra*. *Tithi* depends on the size and shape of the Moon. *Nakṣatra* is the star near which the Moon is seen. Every day the Moon changes its *Nakṣatra* and completes a round in 28 days. Thus the Indian calendar is eternal.

Nakṣatra tells the position of the Moon among the stars. *Tithi* tells the distance of the Moon from the Sun, because in one *Tithi* the Moon goes 12 degrees away from the Sun. Lunar month is named after the *Nakṣatra* near which the full-moon resides. It is also the *Nakṣatra* which rises at the Sunset and remains visible throughout the night. From the name of the Lunar month the Moon's position is fixed and from it the position of the Sun can be easily calculated. The sun is exactly opposite at the full-moon while both are together at *Amāvasyā.*

Ṛtus are six in number, three in each *Ayana. Ayanas* are two, *Uttarāyana* and *Dakṣināyana. Uttarāyana* means the Sun's northern journey. It begins with *Shishira Ṛtu* at the Winter Solstice on 22nd December of the modern calendar. *Dakshināyana is the southern journey of the Sun which begins with the Varṣā Ṛtu* at the Summar Solstice on 22nd June. *Varṣā, Sarad, Hemanta* are the three *Ṛtus* of *Dakshināyana,* while *Shishira, Vasanta* and *Greeshma* are the three *Ṛtus* of *Uttarāyana.* Each *Ṛtu* consists of two solar months. Nabha and Nabhasya are the two solar months of *Varṣā Ṛtus, which* correspond with 22nd June to 21st July and 22nd July to 21st August. *Iṣā* and *Urjā* are the two months of *Sharad. Isa* corresponds to 22nd August to 21st September. A period from 23rd September to 22nd October means *Urja.* 23rd September of the beginning of *Urja* is the Autumnal Equinox having equal day and night. *Hemanta ṛtu* consists of *Saha* (22 October to 21st November) and S*ahasya* (22nd November to 21st December). 22nd December is the Winter Solstice when *Tapa,* the first month of *Ṛtu Śiśira* begins. The second month of *Śiśira* i.e. *Tapasyā* extends from 22nd January to 21st February. *Mādhu,* the first month of *Vasanta Ṛtu* begins on 22nd February and ends with the Vernal Equinox on 21st March. Then *Mādhava,* the second month of *Vasanta* begins which ends on 21st April. From 22nd April *Greeshma* begins, the first month of which is *Ṣukra.* Its second month *Suchi* begins on 22nd May and ends on 21st June. 22nd June is the Summer Solstice when Nabha and Varṣā begin. Thus the solar seasonal months of *Ṛtus* correspond with the modern seasonal months (*Taittirīya Samhitā* 4.4.1. Also *Viṣhṇu Purāṇa Ansha* 2, *Adhyāya 8, Śloka* 83).

Viṣṇu Purāṇa 2.8. 70 clearly speak about two solar months forming *Ṛtu.*

Ancient authors are particular in give *Tithi, Nakṣatra,* lunar month and *Ṛtu.* Sages are particular to mention the *Nakṣatra* of the Sun at the Winter Solatice or the Summer Solstice or the equinoxes. From these records it is evident that the ancient sages knew of the precession of Equinoxes due to which the Sun recedes in the *Nakṣatra Cakra.* If we know the rate of the precession of equinoxes as one degree in 72 years or one *Nakṣatra* in 960 years or one *Rashi* i.e. 30 degrees in 2160 years, we can calculate the year or the period of any incident about which these records are available. We get the data for calculations if the *Ṛtu* and lunar month is given, because the lunar month indicates the Sun's position in *Nakṣatras* while *Ṛtu* indicates the Earth's position in relation to the Sun. Let us now see how precise is the method to fix the dates or years or period of some incidents.

Pañcānga means five important points regarding the time. These are *Tithi*, *Nakṣatra*, *Māsa*, *Ṛtu* and *Ayana.* In addition to these five, the sages were particular to record the positions of the planets, which pinpoint the time.

In the epic *Mahābhārata*, Maharshi Vyāsa gives the positions of all the planets in Bhishma Parva, *Adhyāya* 2,3, thus – Saturn in *Pūva*, Jupiter in *Śārvaṇa*, *Rāhu* in *Uttara Āṣāḍha* and Mars in *Anuradhā*. All these planets have a fixed rotational period. Saturn completes one rotation in 29.4545832 years. Jupiter takes 11.863013 years for one rotation. *Rāhu* takes 18.5992 years, Mars takes 1.88089 years per rotation. Taking the respective positions of each of these planets in any year we can calculate backwards to find out when the planets were in the said positions. I found the year to be 5561 years before Christ. When Bhishma died it was Winter Solstice and he had fought for ten days and had lied on the arrow bed for 58 days. 68 days earlier than 22nd December is 16th October when the Great War must have commenced. Thus we could fix the date of the *Mahābharata* war exactly as 16th October 5561 B.C. Three more planets are found described by Vyāsa in the *Mahābhārata* under the names of *Shveta*, *Shyama* and *Teevra*. These are Uranus, Neptune and Pluto. Calculating back we can find that the respective positions get confirmed on the above date. In addition Vyāsa describes two consecutive *Amāvasyās*, one *Kṣaya Pakṣa,* two eclipses lunar and solar in one month's time and a big comet. All these evidences show the same date 16th October 5561 B.C. Eighteen mathematical points converge on this date and many other evidences point to the same date. Therefore we have to accept it as the date of the beginning of the *Mahābhārata* war.

Accepting this date we can fix the dates of about sixty incidents from the *Mahābhārata* including the date of exile 4th September 5574 B.C. and exposure of Arjuna on 16th April 5561 B.C.

Except Astronomy no other method can give such details and exact dates. In the case of the *Mahābhārata* we have to solve some riddles put forth by the sage Vyāsa deliberately, but in another books no such problem arises.

Ṛtus and lunar months as described in the *Mahābhārata* point to the same time of 5561 B.C. The planet Saturn had been in the arms of Rohini according to the *Mahābhārata.* According to the calculations of late Shri Dixit S.B. this phenomenon took place for many centuries before 5294 B.C.

At the time of Rāma's birth five planets were exalted according to *Vālmīki Ramāyaṇa.* The exalted positions well-known in astrology are thus : Sun 10° in *Meṣa*, Mars 28° in *Makara*, Jupiter 5° in *Karka*, Venus 27° in *Meena*, Saturn 20° in *Tulā*. For calculations of thousands of years only the slow moving planets are useful and only by two planets Saturn and Jupiter we cannot fix the exact date. At least three planets are essential. In the *Vālmīki Rāmāyaṇa,* it is stated at *Ayodhya Kāṇḍa* 4/18 that the Sun, Mars and Rāhu were aspecting *Dasaratha's Nakṣatra* at the time of Rāma's coronation on *Caitra Śuddha* 9th, when Rāma completed 17 years of his life. In the *Caitra Māsa* Sun resides in *Meṣa* Rāśi, so Rāhu also must have been *Meṣa* or just opposite in *Tulā* Rāśi. Rāhu completes one rotation in 18.5992 years, hence 17 years earlier Rāhu must have been in

Kanyā i.e. Virgo. Calculations on this data show the date of Rāma's birth as 4th December 7323 years B.C.

Instead of coronation Rāma had to leave for forest in *Hemanta Ṛtu* on *Caitra Śuddha* 9th. At this occasion Vālmīki states the star positions at Ayodhyā 41/10, 11. These tally with the modern mathematics. Rāma went to the forest life on 29th November 7306 B.C. Rāma was married to Sitā on 7th April 73-7 B.C., in *Bhadrapada Śuddha* 3rd on *Uttarā Phālgunī Nakṣatra.*

When Hanumāna returned after burning Lankā, Vālmīki describes the sky vividly, which indicates the date as *Pouṣa* Krishna 1st or 3rd September 7292 B.C. The war was fought from 3rd November to 15th November 7282 B.C.

I have fixed almost 40 dates of various important events from the *Rāmāyaṇa*, showing that the astronomical records are helpful in fixing dates in history.

Vedic literature records abundant astronomical data, which can fix the periods. Ṛigveda 10161-13 states – "Who awakened Rubhus ? The Sun replied, "The Dog, because today is the end of the year." The Dog means Canis major or *Mṛga Nakṣatra*. Rubhus means clouds. Clouds were awakened by *Mṛga* means rains began with *Mṛga*. At present rainy season begins with *Mṛga*. Thus a cycle of 27 *Nakṣatras* must have been elapsed between the present age and the Vedic age. At the rate of 960 years per *Nakṣatra* 27 *Nakṣatras* have taken 25920 years. So the Vedic statement is 25920 years old. In other word the period of Ṛgveda is 23720 years B.C.

Taittirīya Samhitā 7-4-8 states that *Pūrva Phālgunī* is the last night of the year while *Uttara Phālgunī* is the first night of the new year, and *Vasanta* is the mouth of the year. This shows the Vernal equinox in the month of *Phālguna* at the full Moon. Naturally, the Sun was diagonally opposite in the *Bhādrapada Nakṣatra* at the vernal equinox showing a period of 23720 years B.C.

Ṛgveda 4-57-5 requests *Shunasirau* to shower the water made in heavens on the Earth. *Shuna* means god. *Sirau* means two heads. Two heads of dogs means Canis major and minorine *Mṛga Nakṣatra*. This suggests beginning of the rainy season at *Mṛga Nakṣatra* the period being 23720 years B.C.

The equinoxes recede backwards through *Nakṣatra*. So from *Mṛga* it must have gone to *Kṛttikā*. To show it there is an evidence in the names of the Stars *Kṛttikā*. The constellation *Kṛttikā* is formed of seven small stars, which are named as *Ambā*, *Dulā*, *Nitatni*, *Abhrayanti*, *Meghayani*, *Varṣāyanti*, *Cuputikā* (*Taittirīya Brāhmaṇa* 3-1-4). All these names indicate water. *Abhayanti* means bringing *Abhra* i.e., white clouds. *Meghayanti* means bringing water-loaded black clouds. *Varṣayanti* means bringing showers of rains. At the beginning of rainy season first white clouds of *Abhra* come, then *Megha* or water-loaded clouds come and then showers come. Thus these names definitely point to the rainy season. *Kṛttikā* was bringing the *Varṣā Ṛtu* during 21800 years B.C.

Between *Mṛga* and *Kṛttikā* there is *Rohiṇi*. The rainy season must have begun on *Rohiṇi* some time. It is reported in the *Mahābhārata Vana Parva* 230 wherein it is also stated that the fall of *Vega* or Abhijit began because of *Kṛttikā* went to water i.e. Summer Solstice when *Varṣā Ṛtu* began. This was the condition around 21800 years B.C. Before this, during 22760 years B.C. the Summer solstice was at the *Rohiṇi*.

Apabharaṇi is a Vedic name of *Bharaṇi Nakṣatra*. It was called as *Apabharaṇi* because it was filling water. How a *Nakṣatra* from the sky fill water on the earth? Of course by inducing rains. Thus this name was given around 20840 B.C.

The deity of *Mūla Nakṣatra* is mentioned as *Niruti*. *Nairutya* means southwest. The sages discovered that the rainy season in India comes from southwest winds. Therefore they fixed the deity when *Mūla* was at the summer solstice and introduced rains during 11240 B.C.

Before *Mūla, Pūrva Āṣāḍha* used to induce rains so that its deity is fined as water during a period of 12200 B.C.

Ṛgveda 1-164-19 states, "*O Indra and Soma, you two rotating like a yoked horse are supporting this work.*" These rotating deities are nothing else but the solstices. That time *Jyeṣṭhā* was at the summer solstice whose deity is Indra, and Mṛga whose deity is Soma was at the winter solstice. This period is 10280 B.C.

Taittirīya Brāhmaṇa 1-5-1-6.7 states that *Kṛttikā* to *Viśākhā* is the northern course of the Sun while *Anurādhā* to *Āpabharaṇi* was the southern course of the Sun. This clearly shows that the winter solstice was between *Kṛttikā* and *Bharaṇī* i.e. 26″ 40′ while the summer solstice was between *Viśākhā* and *Anurādhā* at 213″ 20′. On 22nd December 1995 the Sun is at 245″ 50′ 45″ in *Mūla Nakṣatra* on the winter solstice. It has come here from 26″ 40′. So total shift back is 140″ 49′ 15″. The rate of the precession of equinoxes is 50.2 per year. So it is seen that 10098. 704 years ago the statement is written. It comes to 8103 years B.C.

Āśvalāyana Gṛyhya Sūtra 2-3-5 advises to meditate on *Hemanta Ṛtu* on *Margasīrṣa Pūrṇimā*. Naturally, *Hemanta* was ending at *Māgha Pūrṇimā* on the winter solstice. The full Moon at *Māgha* shows the Sun to be at 307″ at winter solistice. At present the winter solstice occurs at 246″. It shows that the Sun has receded back by 61″. The precession rate is 72 years per degree. So 61X 72 = 4392 years ago *Āśvalāyana Gṛyhya sūtra* is written. It shows 2404 B.C. at least 1900 B.C. as its period.

ŚuśrūtaSamhitā 6-10 tells rainy season in *Bhādrapada* and *Āśvina Masas*. It was the condition around 400 B.C. The Samhitā also states that *Māgha Māsa* and *Śishira Ṛtu* began together. This indicates 2000 B.C. Thus it appears that the first edition of *ŚuśrūtaSamhitā* was formed in 4000 B.C. while the second edition was prepared at 2000 B.C.

Maitrāyaṇi Upaniṣad 6/14 records the summer solstice at the beginning of the *Māgha Nakṣatra* or at 120°. At present it is at 65° 40′ 42″. The difference is of 54° 19′ 18″ or

195558 seconds. The precession rate is 50.42″ per year. It shows that *Maitrāyaṇi Upaniṣad* is composed 3895,5776 years ago or 1909 B.C.

Vishnu Purāṇa tells at 2/8/66 to 76 that equal day and night come when the Sun entered *Meṣa* or *Tula Rāsi*. It shows a period not later than 1609 B.C.

Vedānga Jyotiṣa shows the winter solstice on *Dhaniṣṭhā* which cannot be later that 1640 B.C.

Parāśara tells Summer solstice at middle of *Aśleṣ*ā at 113° 20′. Its date comes to 1159 B.C.

Kauśitakī or *Śankhāyāna Brāhmaṇa* 1/3 tells that in the middle of the rainy season one should see at the *Pūnarvasu Nakṣatra* while offering oblation. But in these days in the first fortnight the Moon does not combine with *Punarvasu*. Therefore give oblation on *Amāvasyā*, which comes after *Āṣāḍha*, because on the *Amavasyā* there is *Purnavasu Nakṣatra*.

In the first fortnight of *Punarvasu* is invisible in the months of *Pauṣa* to *Āṣāḍha*. These are omitted. It shows that Jeshtha and *Āṣāḍha* were not the months of rainy season It is suggested to use *Amavasyā* coming after *Āṣāḍha*. Thus it appears that the rainy season used to begin from *Śrāvaṇa Māsa*. At present the rainy season begins from *Jeṣṭha Māsa*. The rainy season has shifted back by two months. It means that the Sun has receded 60°. At the rate of 72 years per degree the shift must have taken place in 4320 years. Thus *Kauśitakī Brāhmana* appears to be written around 2320 B.C.

Matsya Purāṇa 204/5 tells that if one oblates on the *Trayodaśi* with *Māgha Nakṣatra* during *Varṣā Ṛtu* he gets benefited. *Māgha Nakṣatra* on *Trayodaśi* comes in *Sārvaṇa* on *Bhadrapada māsa*. Thus these two were the months of *Varṣā Ṛtu* when *Mātsya Purāṇa* is composed. The period is around 200 B.C.

Shrimad Bhāgavata Purāṇa shows equal day and night when the Sun was in *Meṣa* or *Tula Rāśi*. It shows the time to be 1600 to 2000 B.C.

Kālidāsa describes *Varṣā Ṛtu* from *Āṣāḍha* first day. From that he appears to be at the beginning of the Christian era i.e. 2000 years ago since today.

Varāhmihira gives the summer solstice at *Karkadya* i.e. at 90°. So his date is 520 A.D.

Thus all the steps of one to two thousand years are shown by Astronomy. This cannot be done by Archaeology or linguistics of any other science or method. There is a gap from 12000 B.C. to 20000 B.C. which can be filled up by stray evidences such as the fall of *Vega* (Abhijit) mentioned in the *Mahābhārata* which took place around 13000 B.C. Vālmīki Rāmāyaṇa states that *Daityakula* had *Mūla* as their *Nakṣatra* and *Ikṣvaku Kula Nakṣatra* was *Viśākhā*. It means that *Daitya Kula* began when Vernal equinox was at *Mūla* i.e. 17000 B.C. *Ikṣvaku Kula* started with *Viśākhā* at the Vernal equinox around 15000 B.C. Thus all the steps of history of the ancient Indian culture are seen ranging from 25000 B.C. to 520 A.D. Only Astronomy can give such fineries about time.

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