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ASTRONOMY AND ŚANKUSTHĀPANAM IN TEMPLE CONSTRUCTION

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In Temple construction, two important things are to be fixed before starting the work. 1. Deriving the auspicious time for Boomi Pooja, Kumbha Abhishekam etc. 2. Fixing the directions exactly (mainly 8, North, East, South, West and the 4 in between). Here Astronomy plays the important role and based on it only the construction proceeds.

Astronomy is the branch of Science that deals with **the study of celestial bodies** (such as stars, planets, satellites, comets, nebulae, star clusters, and galaxies) and phenomena that originate outside the atmosphere of Earth (such as the cosmic background radiation). It is concerned with the evolution, physics, chemistry, meteorology **and the motion of celestial objects,** as well as the formation and the development of the Universe.

The auspicious time is based on the aspects, phenomena and positions of celestial bodies, especially the nine Graha **(not synonym to planets)** and the stars at ecliptic plane of Earth (27 Nakshatra). The positions of Navagraha, with reference to Earth are changing constantly. Hence to assess their positions in the celestial sphere, their motion is to be assessed, with reference to the fixed ecliptic stars. The positions of these ecliptic stars which are constant (fixed, not moving, as for as Earth is concerned) can be ascertained, by creating imaginary celestial co-ordinates, passing through the celestial sphere. These are with reference to the celestial equator which is nothing but the extension of the equator of the Earth. The celestial co-ordinates that pass through the north and south celestial poles, cutting the celestial equator at right angles, are the longitudes and their angle is mentioned as right ascension. They are 360 in total, one for each degree of angle. The celestial co-ordinate that passes exactly at the celestial equator is 0° declination and the co-ordinates that are parallel to this celestial equator are latitudes and their angle is mentioned as declination. That pass through the northern hemisphere are 90 in number (one for each degree) and are denoted with N or +ve sign and the other 90 that pass south to equator are denoted with S or –ve sign. These are celestial co-ordinates of equatorial system. In this system, the declination of the Graha, especially of the Sun, is used in calculating the positions of Graha, relative to the equator of the Earth.

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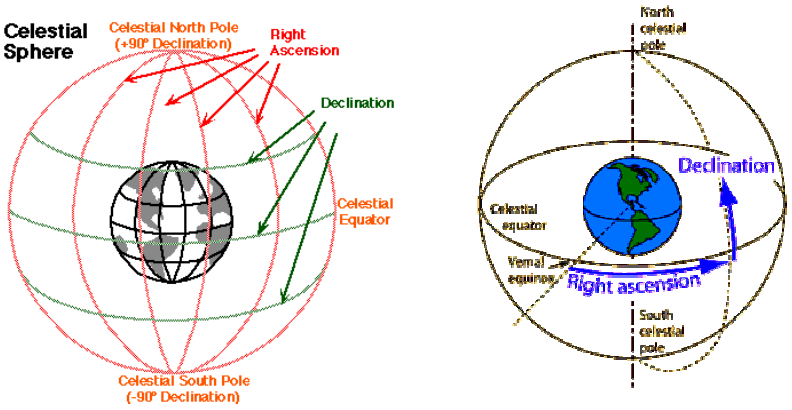
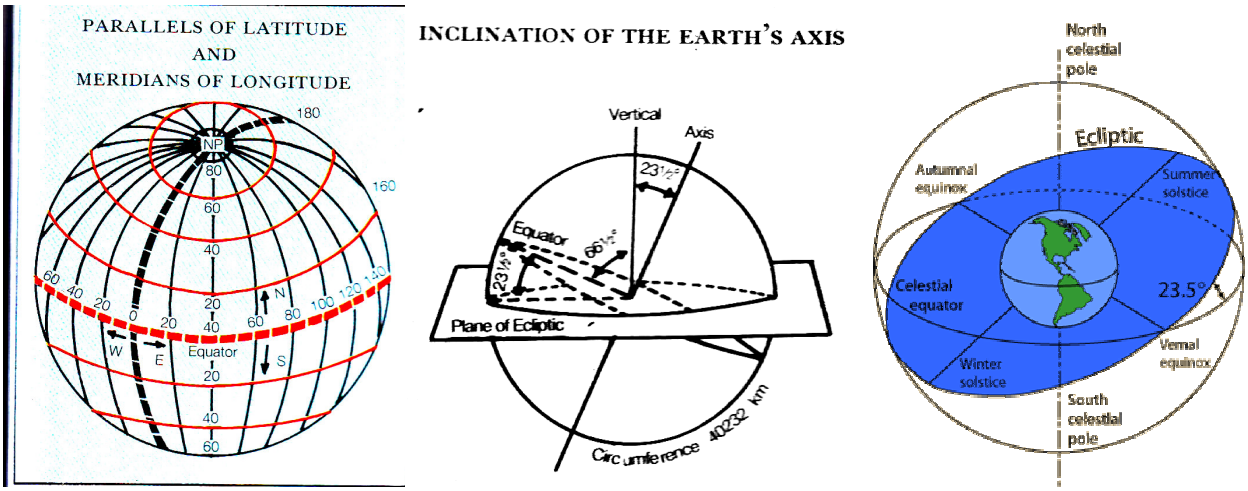
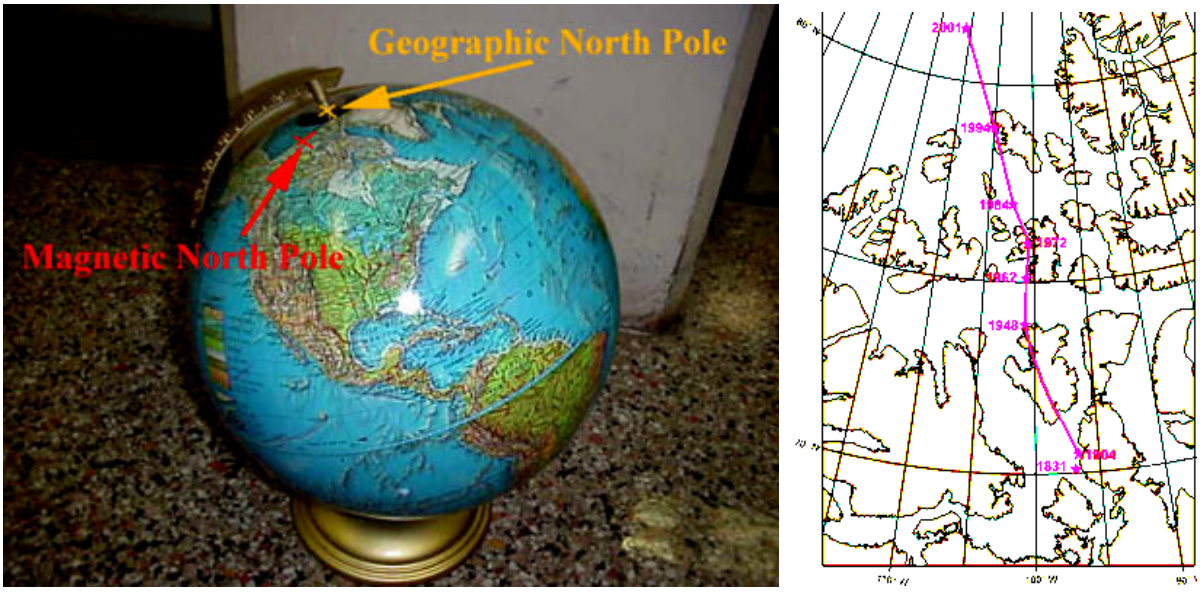


The other system is ecliptic co-ordinates, where the ecliptic of the Earth is the central line and is marked as 0° celestial latitude. The ecliptic is the annual path of the Earth around the Sun. The lines passing parallel to this are the celestial latitudes, 90 northwards and 90 southwards and are marked as N or + and S or –ve sign. The north and south poles of the ecliptic are known as Kadamba in our Nation's astronomy and the longitudinal lines passing through these ecliptic poles, cutting the ecliptic at right angles are the celestial longitudes and are 360 in number, one for each degree. These celestial co-ordinates of ecliptic system are used to fix the positions of the Graha. Thus, the positions of Graha are mentioned relative to the Earth's position in the ecliptic and not with reference to the celestial sphere and this itself proves that these co-ordinates were developed in our Nation and spread to the whole world. This is because, in our astronomy, the positions of Graha are assessed with reference to Earth's position in the ecliptic, there by understanding the effect of Graha on Earth, where as in the western astronomy they are described with reference to the celestial sphere. These co-ordinates are the celestial longitudes and latitudes. The co-ordinates of ecliptic and equatorial systems differ by 23° 27` at the maximum at solstices and 0° at equinoxes, as the Earth is inclined at its axis by 23° 27` to its ecliptic path around the Sun.



The longitudes and latitudes of the Earth are same as that of right ascension and declination of celestial sphere. The longitudes pass through the North and South poles (Dhruva) of Earth, cutting the Equator of the Earth at right angles. They are 360, one for each degree. The prime meridian is 0° longitude and the other longitudes are mentioned as East, if they are east to this prime meridian and west if they are west. The latitudes of the Earth pass parallel to equator of the Earth (0° latitude) and the latitudes (90) in northern hemisphere are denoted as N or +ve sign and the southern latitudes (90) are denoted as S or –ve sign. These are of equatorial system and they are also important in arriving the auspicious time, as the effect of Graha varies at different longitudes and latitudes on the Earth. Besides, these co-ordinates of the Earth and the declination of the Sun are important in fixing the direction, at the place of temple construction.

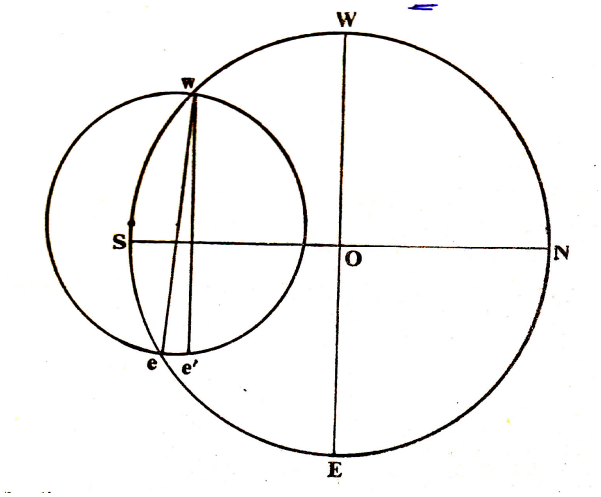
Magnetism is not useful in fixing the directions exactly. This is because, the north magnetic pole is on Ellef Ringnes Island in northern Canada, about 870 miles from the geographic North Pole. The south magnetic pole is off Wilkes Land, Antarctica, about 1,710 miles from the geographic South Pole, as shown in the figure.

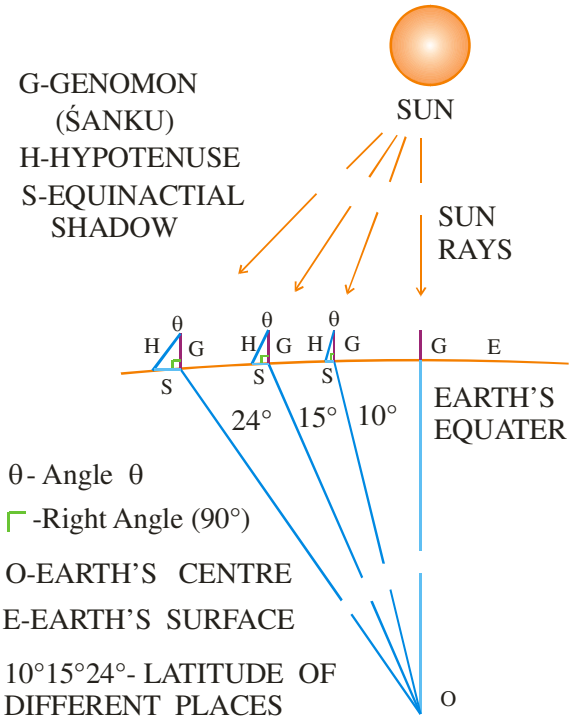


Moreover, their positions vary at different periods of time. For example, the North Magnetic Pole moves slowly over time, due to magnetic changes in the Earth's Core. In 2001, it was determined by the Geological Survey of Canada to lie near Ellesmere Island in northern Canada at 81.3°N, 110.8°W. It was estimated to be at 82.7°N, 114.4°W in 2005. In 2009, it was moving toward Russia at between 34 and 37 miles (55-60 km) per year. The positions of North Magnetic Pole at various periods are 81.3°N, 110.8°W (2001), 82.3° N, 113.4°W (2004 est.), and 82.7°N, 114.4°W (2005 est.) and of the South Magnetic Pole are 64.6 ° S, 138.5 ° E (1998), 63.5 ° S,

138.0 ° E (2004 est.) and 64.487 ° S, 137.684° E (2007). Hence, an alternate method, for the exact fixation of the directions, is required. Fixing the directions is a very essential basic thing, in temple constructions, because the places and front view of various Deities should be exact, as mentioned in temple architecture, Āgama and Veda. For this, our ancestors developed a system and method, using Astronomy and the Śanku. The Śanku is a Gnomon, usually a wooden, cylindrical, massive, straight rod (pillar, pole) of 12 Angula (1/2 cubit) height.

Using this Śanku, the directions are fixed exactly, by the following method. It is carried out on an equinoctial day, when the Sun raises exactly in straight line at Celestial (Earth's) equator (0° declination) . In the following figure, ESWN is a circle on a level ground. O is the centre of circle (Śanku). The 'w' is the point at which the tip of the shadow of Śanku enters into the circle in the forenoon. The 'e' is the point at which the tip of the shadow of Śanku goes out of the circle in the afternoon. Then, 'ew' is the East West line. With fish arcs (Timi or Matsya), north south line is fixed. (Next figure shows that the length of the shadow varies at different latitudes of the Earth).





But, declination of the Sun varies from forenoon to afternoon, as the Sun's Declination (δ) undergoes change continuously. It is due to the inclination of the Earth and is 23° 27 `. So in a year, i.e. during the Uttarāyaṉa (23° 27 ` × 2, from the line of Capricorn to the line of Cancer) and Dakshināyana (23° 27 `× 2, from the line of Cancer to the line of Capricorn) of Sun, it is 23° 27 ` × 4 = 93° 48 ` in 365.256364 days. However, the amount of variation depends on the declination

of the Sun. It is maximum up to 24` when the declination is 0 ° i.e. on equinoctial days and almost zero when the declination is 23° 27 ` i.e. on solstice days. Hence, the directions vary, very slightly from 'ew' to 'e`w' as shown in the figure. The difference between 'e' and 'e`' is 'd' and can be calculated, by the following method. Sun's declination on a particular day of a year is already computed and is available for all the days of a year. Hence, the values of δ and δ` can be calculated. ( δ is the declination of the Sun on the forenoon and δ` is the declination of the Sun in the afternoon, at the time of 'w' and 'e' markings, respectively).

The distance of the shadow-tip from the east-west line is defined as the *chāyā-bhuja* ("*bhuja* or base of shadow"). Let the difference between the *chāyā-bhuja* when the tip of the shadow enters into the circle and the *chāyā-bhuja* when the tip of the shadow passes out of the circle be *d*. Let δ be the Sun's declination when the tip of the shadow enters into the circle in the forenoon and δ′ the Sun's declination when the tip of the shadow passes out of the circle in the afternoon. Then

$$d = \frac{(R\sin\delta' \sim R\sin\delta) \times \text{hypotenuse of shadow}}{R\cos\phi},$$

where ϕ is the local latitude. This *d* denotes the correction which is applied as follows :

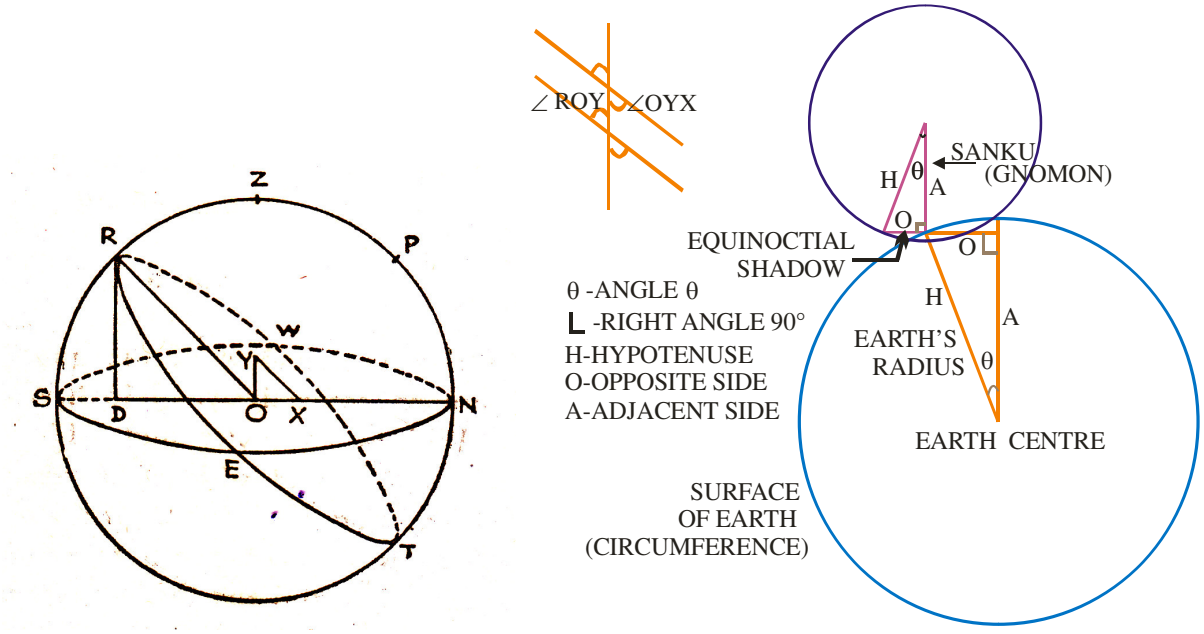
Construct a circle with ew as diameter, and with centre e and radius *d* draw an arc cutting this circle at e′ towards the north if the Sun's *ayana* is north, or towards the south if the Sun's *ayana* is south. Then e′w is the true orientation of the east-west line.

Now, through O, draw a line EW parallel to e′w. Then, relative to the point O, E is the east and W the west. The line NS, drawn through O, at right-angles to EW is the north-south line, N being the north and S the south relative to O.

Here, Rsine θ is local latitude. The value of Rcos θ (local co-latitude) and the local latitude Rsine θ can be calculated by using the Śanku, on the equinoctial day or in any other day by taking into consideration of the Sun's declination on that particular day, as shown in the following figures.

NESW is Horizon, NESW are directions, Z is Zenith of the local place, ZRSTNP is Local Meridian, R is the point of intersection of local meridian and Celestial Equator, RETW is Equator,

O Local Place, RD is perpendicular (⊥) to Horizon, Sun is at R at mid noon and Zenith at equator, OY is Śanku and is perpendicular (⊥) to Horizon, OX is its equinoctial mid shadow, XY is its Hypotenuse, RO is celestial radius, Arc RZ (∠ROY) is Local Latitude.



1. Δ RDO similar to Δ YOX, 2. ∠ROY= ∠OYX = ∠ DRO (RO and YX are Parallels and because the line OY cut these parallels, the opposite angles ∠ROY= ∠OYX are equal in degrees, as shown by the orange lined figure, inserted at the top. In the same way, RD and OY are parallels and the line RO cuts them, hence ∠ROY = ∠ DRO), 3. All these three are angle θ, 4. Rsine θ is local latitude, 5. ∠OYX is angle θ, in Śanku triangle Δ YOX, 6. ∠RDO =∠YOX = 90 °.

Latitude of any place on the surface of the Earth is R sine θ of this Śanku Triangle, where θ is the angle between the Śanku and the hypotenuse. R sine θ is known as Jyā (String) or exactly Ardha Jyā (1/2 String) of a Bow and Arrow, in our Hindu Astronomy. **This Jyā became Sine in Western world, on spread from Bhārat.** R cos θ = R × Adjacent side ÷ Hypotenuse and R sine θ = R × Opposite side ÷ Hypotenuse. Adjacent side is Śanku and opposite side is the shadow of Śanku and from the height and shadow of the Śanku, Hypotenuse is derived. Hypotenuse is equal to $\sqrt{[(\text{Śanku})^2 + (\text{Shadow of Śanku})^2]}$. Hence, Latitude Rsine θ = 3438` × Shadow of Śanku ÷ $\sqrt{[(\text{Śanku})^2 + (\text{Shadow of Śanku})^2]}$. Here Śanku is of 12 Angula in length (we can keep any length) and Shadow of Śanku is at exactly mid noon of the place concerned, on the equinoctial day. So, its termed as equinoctial mid shadow. R is 3438 minutes of angle, because 2πR is 360° (2πR is circumference of circle, which is 360° always). So, R is 3438` (360 ° ÷ 2 π). Thus, by

using the Śanku and the fore detailed calculations, both developed and practiced in our Nation in the remote past, we can fix the directions exactly, at the place of construction of the Temple and it is the very reliable, exact and correct method in fixing the directions. The R sine θ (Ardha Jyā) values, including its computation and derivation for the angles of a circle, from 3° 45 ` to 90 ° at intervals of 3 ° 45 ` (totally 24 values) are given by Āryabhaṭṭa, in 2741 B.C.E. in his Astronomical and Mathematical text Āryabhaṭṭīyam, in 11 and 12 śloka of 2nd Addhyāyaḥ (Ganita Pādaḥ). Sūrya Siddhāntaḥ gave these values in 16 to 23 śloka (including values of versed sine, Utkrama Jyā) of 2nd Adhyāyaḥ (Sputa Gatiḥ). Value of Ardha Jyā for 90 ° is 3438`, where the length of the chord (string of the bow) is equal to the radius of circle.

This method and science of fixing the directions exactly, at any locality on Earth, by using the Śanku and these calculations, are detailed well in the ancient astronomical texts of our Nation, in the remote past itself. 1. Sūrya Siddhāntaḥ of remotest antiquity, in its 1 to 8th śloka of 3rd Adhikāraḥ (Tripraśnādhikāraḥ), 2. Mahāryabhaṭṭa Siddhāntaḥ, written by Āryabhaṭṭa, nearer to the beginning of this Kaliyuga (4700 years before present) in the 1 to 6th śloka of 4th Adhikāraḥ (Tripraśnādhikāraḥ), 3. Pañca Siddhāntikā of Varāhamihira of 123 B.C.E. in 19 to 21st śloka of the 4th Adhyāyaḥ (Karaṉādhyāyaḥ) [21st śloka deals with the method of using the shadow of any day in a year, to fix directions], 4. Brahmasphuṭa Siddhāntaḥ of Brahmagupta (30 B.C.E.) in 1 to 5th śloka of 3rd Adhikāraḥ (Tripraśnādhikāraḥ), 5. Siddhānta Śiromanī of Bhāskarācārya (486 B.C.E.) in 8 and 9th śloka of 3rd Adhikāraḥ (Tripraśnādhikāraḥ) of Golāddhyāyaḥ, 6. Mahābhāskarīyam of Bhāskara (522 /629 C.E.) in 1 to 5th śloka of 3rd Addhyāyaḥ 7. Laghu Bhāskarīyam of Bhāskara 1 to 4th śloka of 3rd Addhyāyaḥ 8.Vateśvara Siddhāntaḥ and Gola in the 2 to 5th śloka of 1st Adhyāyaḥ (Viṣuvachāyāsādhanvidhiḥ) of the 3rd Adhikāraḥ (Tripraśnādhikāraḥ) [It mentions the correction to be done due to variation in declination of the Sun, in a single day], 9. Śiṣyadhīvṛddhita Tantram of Lallācārya in 1 to 7th śloka of 3rd Adhikāraḥ (Tripraśnādhikāraḥ), and 10. Goladīpikā of Parameśvara in 1 to 53rd śloka of 4th Addhyāyaḥ, all these ancient astronomical and mathematical texts of our Nation, described this method.

Even the ancient non-astronomical texts are also describes it, at times. For example, "Neḍunal Vāḍai" a very ancient Sangham Tamil Literature of Patthuppāṭṭu texts, describes it as follows.

"…… māthiram virikathir parappiya viyalvāy maṉḍilam,

Erukol kurinilai vazhukkātha kuḍakkerbu, oruthiram cārā arai nāl amaiyatthu,

Nūlari pulavar nunnithir kayiriṭṭu, Deyem koṉḍu Deiva nokkip

Perum peyar mannarkkoppa manai vakutthu,……'' (72 to 78 lines)

The meaning is "The Sun, rising at east, proceeds towards west. On the day, exactly at mid noon, at which there were no shadows, neither on north or south side of the two Śanku (wooden sticks), the experts of civil engineering, who knew well the texts of civil engineering and architecture (Śilpa Śāstram), fixed the directions, at that place with ropes, after worshiping God and thus started constructing a great palace for the great King."

The two Śanku will not cast their shadows at their northern and southern sides, at exact mid noon only on a day, when the local latitude of that place and the declination of the Sun are exactly equal. That means, on that particular day, the Sun rises in the east exactly in the line of the latitude of that place and the Sun is exactly at the zenith of that place, at exact mid noon, on that day. Thus, our ancestors knew the Sun's declination (and other celestial co-ordinates) and the latitude co-ordinates (and other co-ordinates) of the Earth. This can be proved by the following evidences.

1. The list of 27 ecliptic stars and their co-ordinates

Sūrya Siddhāntaḥ in 2 and 57th śloka of 1st Adhikāraḥ (Madhyamādhikāraḥ) clearly reveals that this text was taught at the end of Kṛta Yuga of the present 28th Mahāyuga i.e. 12,96,000 + 8,64,000 + 5,112 = 21,60,112 years before present. Śloka 8 and 9th of 1st Adhikāraha mentions that it was taught every Yuga to Saints (Ṛṣi) by Bhāskara (Sun God) i.e. even at a period, prior to this. The 8th Adhikāraḥ (Nakṣatragrahayutyadhikāraḥ, 1 to 21st śloka) gave the Polar Longitude (Dhruvaḥ, Dhruvakam) and Latitude (Vikṣepaḥ) of all 28 Ecliptic stars, in the following table. Bhāskara's Mahābhāskarīyam and Laghu Bhāskarīyam, Lallācārya's Śiṣyadhīvṛddhita Tantram, Brahmagupta's Brahmasphuṭa Siddhāntaḥ and Khaṉḍa Khādyaka, Śrīpati's Siddhānta Śekara, Bhāskarācārya's Siddhānta Śiromaṉī also gave the celestial longitudes and celestial latitudes of these 27 ecliptic stars.

Asterisms.	YOGA-TÁRÁS *or principal stars.*	*Apparent longitudes,*			*Apparent latitudes*	
		s	°	′	°	
As'winí,	α Arietis,	0	8	0	10	N.
Bharaṇí,	Musca,	0	20	0	12	N.
Krittiká,	π Tauri, Pleiades,	1	7	30	5	N.
Rohiṇí,	α Tauri, Aldeharan,	1	19	30	5	N.
Mríga,	λ Orionis,	2	3		10	S.
Ardrá,	α Orionis,	2	7	20	9	S.
Punarvasu,	β Geminorum,	3	3		6	N.
Pushya,	δ Cancri,	3	16		0	N.
As'leshá,	α 1 and 2 Cancri,	3	19		7	S.
Maghá,	α Leonis, Regulus,	4	9		0	N.
Purvá-phálguní	δ Leonis,	4	24		12	N.
Uttará-phálguní,	β Leonis,	5	5		13	N.
Hasta,	γ or δ Corvi,	5	20		11	S.
Chitrá,	α Virginis, Spica,	6	0		2	S.
Swátí,	α Bootis; Arcturus,	6	19		37	N.
Vi'sákhá,	α or χ Libra,	7	3		1	30′ S.
Anurádhá,	δ Scorpionis,	7	14		3	S.
Jyeshṭhá,	α Scorpionis, Antares,	7	19		4	S.
Múla,	ν Scorpionis,	8	1		9	S.
Púrváshádhá,	δ Sagittarii,	8	14		5	30′ S.
Uttaráshádhá,	τ Sagittarii,	8	20		5	S.
Abhijit,	α Lyri,	8	26	40′	60	N.
S'ravaṇa,	α Aquilæ,	9	10		30	N.
Dhanishṭhá,	α Delphini,	9	20		36	N.
S'ataṭáraká,	λ Aquarii,	10	20		0	30′ S.
Púrvábhádrapadá,	α Pegasi,	10	26		24	N.
Uttarábhádrapadá,	α Andromedo,	11	3		26	N.
Revatí,	ζ Piscium,	11	29	5	0	0 N.

2. The astronomical terms and the names of these co-ordinates

These are given in these ancient astronomical and mathematical texts, at the remote past itself. This clearly proves that our ancestors had expertise knowledge in astronomy, including co-ordinates and they applied them in their day to day life. The following is the glossary of astronomical terms, though it is not a complete collection.

Agrā – Amplitude; Ahorātravṛtta – Diurnal circle; AkṣaAmsa (Akṣāmsa) – Latitude of a place; Akṣajyā – R sine Latitude; Akṣabhā, Palabhā –Equinoctial Mid Shadow; Akṣakarṇa, Chayākarṇa – Hypotenuse in Śanku triangle; Akṣakoṭi – Co-latitude; Akṣonnati – Inclination of Earth's Axis; Apakrama, Paramakrānti – Greatest Declination; Apakramavṛtta, Apamaṇḍala, Krāntimaṇḍala, Krāntivṛtta – Ecliptic; Ardhajyā – R sine; Avanama – Zenith Distance; Ayanānta – Solstice;

Ayanacalana – **Oscillation** of Equinox; Bhūgola – Earth; Gola – globe, sphere; Candrakarṇa – Distance of Moon from Earth; CandraPāda – Nodes of Moon (Rāhu and Ketu); Dṛgjyā - Rsine of Zenith; Dīrghāmsa, Desāntra – Longitude of a place; Dṛggola – Visible Celestial Sphere; Dṛkṣepa – Ecliptic Zenith Distance; Dṛkṣepamaṇḍala – Vertical circle through central ecliptic point; Dṛkmaṇḍala – Visible vertical circle; Dṛgamascāpa – Zenith Distance; Dhruva – Pole; Dhruvaka – Polar Longitude; Jyā – R sine; Hora – 1/24 th of a day; Kadamba – Pole of Ecliptic; Kakṣa – Orbit; Kapāla – Hemisphere; Koṭijyā – R cosine; Koṭi – Perpendicular Side of Right Angled Triangle; Krānti, Apama – Declination; Krāntijyā – Rsine declination; Krāntipāda – Eqinox; Kṣipti, Śara – Celestial Latitude; **Ksitija, Harija – Horizon (Vateśvara Gola 3-2)**; Lambajyā – Rsine of co-latitude; Lambāmsa – Co-latitude in degrees; Lambana – Parallax of Longitude; Maṇdanīca – Perigee and Perihelion; Maṇdocca – Apogee and Aphelion; Nāḍivalaya, Viśuvadvalaya, Nāḍivṛtta, Viśuvadvṛtta – Celestial Equator ; Natakāla – Hour Angle; Nati, Avanati – Latitudinal Parallax; Nīcocca Vṛtta –Epicycle; Parama Lambana – Horizontal, maximum parallax; Paridhi, Nemi – Circumference; Pūrvāparā – East West Line; Ravikarṇa – Distance of Sun from Earth; **Rekhā, Madhya Rekhā – Prime Meridian, Lańka and Ujjainī (Line of Prime Meridian)**; Samamaṇḍala – Prime Vertical; Sphuṭavikṣepa – Celestial Latitude corrected by Parallax; **Śanku – Gnomon, Rsine Latitude**; **Trijyā – Rsine of an arc of 90 °**; Unnati, Unnata – Altitude; Udvṛtta, Unmaṇḍala – Equinoctial, 6'o clock, east west circle; Vidigvṛtta – Intermediate Cardinal Points; Vikṣepa – Celestial Latitude of a Graha (Polar Latitude); Vimaṇḍala – Orbit of a Graha; Viśuvat – Equator; **Vṛtta – Circle (Vertical)**; Yamayotravṛtta – The Local Meridian passing through North South Cardinal Points. These are all the some of the astronomical terms used in the ancient astronomical texts of our Nation, showing the richness of our ancestor's knowledge in astronomy.

3. Reference of Lańka Ujjianī Prime Meridian in our Nation's ancient astronomical texts

A. Sūrya Siddhāntaḥ 37 to 42, 52, 70 and 71st śloka of 12th Adhyāyaḥ mentioned about Lańka, as a great city situated in the southern part of our Nation Bhārata, on Earth's Circumference

(Equator) [39th śloka]. It mentioned 4 cities, 1. Lańka, 2. Yamakoṭi of Bhadrāśva Nation in East, 3. Romaka in Ketumālā Nation in West and 4. Opposite to Lańka is Siddhapuri of Kuru Nation. These 4 cities situated on Earth's circumference at equal distances (90° apart). In these places there is no equinoctial mid shadow (when Sun rises at Equator (Equinox) with 0° declination). Śloka 1-62 mentions Avantī (Ujjainī) in Prime Meridian (Rekhā). This Lańka was situated south-east of Maldives and is different from the present day Srī Lańka.

B. Āryabhaṭṭīyam of Āryabhaṭṭa (2764 B.C.E.) mentions in the 14th śloka of 4th Addhyāyaḥ (Golapādaḥ) as, from the centre of land and water, at a distance of one quarter of the Earth's circumference lies Lańka and Ujjainī lies exactly northwards of Lańka, at a distance of 1/16 of the Earth's Circumference (360° ÷ 16 = 22.5°),

C. Brahmagupta's (30 B.C.E.) Brahmasphuṭa Siddhāntaḥ (21-9th śloka), mentioned that Ujjainī is at 1/15th part of Earth's circumference (24°),

D. Mahābhaskarīyam of Bhāskara (522 /629 C.E.), in 1 and 2nd śloka of 2nd Addhyāyaḥ mentions that Lańka and Ujjainī are in the same meridian,

E. Karaṉaratnam of Devācārya 30th śloka of 1st Addhyāyaḥ mentioned in the same way,

F. Varāhamihira's (123 B.C.E.) Pañcasiddhāntikā, 13th Addhyāyaḥ (Trilokyasamsthānam), 10, 11,17,19, 26 and 32nd śloka, details Ujjainī and Lańka. (Both in same meridian, 17th śloka).

G. Lallacārya's Śiṣyadhīvr̥ddhita Tantram, 3, 4 and 12th śloka of Bhūgolāddhyāyaḥ (17th Addhyāyaḥ) and 24 and 25 śloka of 19th Addhyāyaḥ (Bhuvanakośa) describes Kanyā (Kumārikā) part of Bhārata Nation. Lańka was situated in this part. 40th śloka describes Ujjainī at Prime Meridian,

H. Vateśvara Siddhāntaḥ and Gola 10th śloka of 5th Addhyāyaḥ of Gola part mentioned the four cities including Lańka in Equator, 1 and 2nd śloka of 8th section of 1st Addhyāyaḥ mentioned that Lańka and Ujjainī in Prime Meridian,

I. Sripati's Siddhānta Sekara in 2nd Addhyāyaḥ 95 to 97th śloka mentioned that Lańka and Ujjainī in Prime Meridian

J. Siddhānta Dharpana of Nīlakaṉḍa Somayāji, 15th śloka mentioned that Ujjainī is north to Lańka by 1/15th part of Earth's Circumference (24°),

K. Bhāskarācārya's (486 C.E.) Karaṉakutūkalam 1-14th śloka mentioned that Ujjainī in Prime Meridian (Madhya Rekhā),

L. Goladīpikā of Parameśvara in 3rd Addhyāyaḥ describes the Earth and its divisions. In 8, 9 and 26 to 29th śloka mentioned the four cities including Lańka. The 77 to 91st śloka describes the Nation Bhārat and 92nd śloka after describing the river Ganga, mentioned that Lańka is situated at the top of the mountain in the Malaya Island, one of the six islands of Kumārī Islands situated at the southern most end of Bhārat (Anga, Yava, Malaya, Sankhaka, Kumuda and Varāha), Rivers flown from Malaya mountain were Kr̥tamālā and Tāmpraparaṉī,

M. Laghumānasam of Mañjulācārya 3rd śloka of 4th Addhyāyaḥ mentioned Avantī (Ujjainī) in Prime Meridian. This proves that initially Lańka Ujjainī was the prime meridian and when the westerners copied these co-ordinates from these texts, they changed it to Greenwich.

4. 360 DEGREES OF A CIRCLE AND VEDA

Ṟg Veda Samhitā 1st Maṉḍalam 164th Sūktam (Hymn) 48th Mantram (verse) reveals,

द्वादश प्रधयश्चक्रमेकं त्रीणि नभ्यानि क उ तच्चिकेत ।
तस्मिन्त्साकं त्रिशता न शङ्कवोऽर्पिताः षष्टिर्न चलाचलासः ।।

Dvādaśa pradhayaś cakram ekam trīṉi nabhyāni ka u tacciketa |
Tasmintsākam triśatā na śańkavo'rpitāḥ ṣaṣṭirna calācalāsaḥ ||

Meaning: Dvādaśa– 12; pradhaya**:** – the arcs of a wheel; cakram ekam – one wheel; trīṉi - three; nabhyāni – axles or hubs or centre part of the wheel; triśatā ṣaṣṭi**:** – 360; śańkava**:** – spokes of the wheel; calācalāsaḥ – movable and immovable.

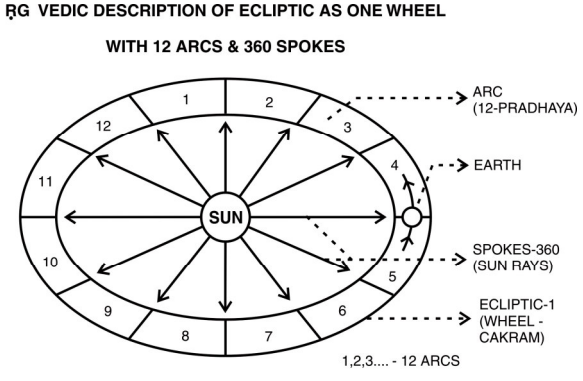


FIGURE - 1

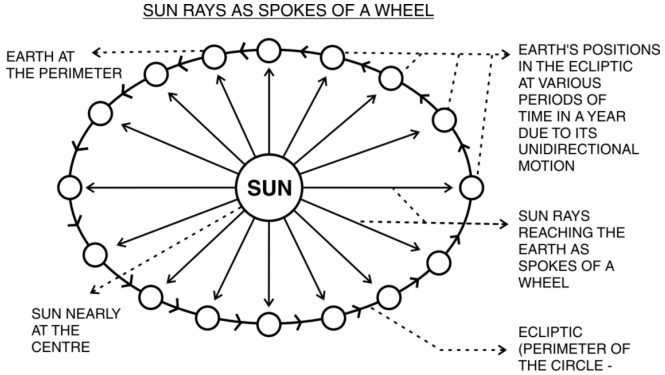


FIGURE - 2

"The arcs are twelve, the wheel is one and three are the axles. Who indeed knows it? Within it are collected three hundred and sixty spokes, which are as it were movable and immovable."

This shows clearly that the time divisions in our Nation, is based on the angular distance covered by the Earth, in its Ecliptic round the Sun, in that particular time. One year is the time required for the Earth to travel 360° (one full circle) of angular distance, in its ecliptic around the Sun. In the same way, one month for 30° (one arc-rāsi-sign), one day for 1° (amsa- spoke), one ghaṭikā (nāḍī-nāḍikā) for one minute (liptā-kalā), one vighaṭikā (vināḍī, vināḍikā) for one second (viliptā, vikalā) and one Gurvakṣara is the time required for the Earth to travel one third (tatparā) of angular distance, in its ecliptic around the Sun. Thus, there is an exact confluence of the spatial distance travelled by the Earth in the Ecliptic in its unidirectional motion and the Time Measurements developed in our Nation. This is completely scientific and is totally based on the angular distance covered by the Earth in the Ecliptic and the time required for that. Thus, the concept of 360° of angles for a circle, is based on Earth's revolution round the Sun in the Ecliptic, as revealed in Ṛg Veda Samhitā verses 1-164-48 and 11. Hence, it is clear that 1. The concept of 360° of angles for a circle and 2. The Time Space and the Direction Concept (Dig Deśa Kāla Vardhamāna) of the most modern science, had been developed scientifically and applied in the day-to-day life, by our Ancestors, in the remotest antiquity itself.

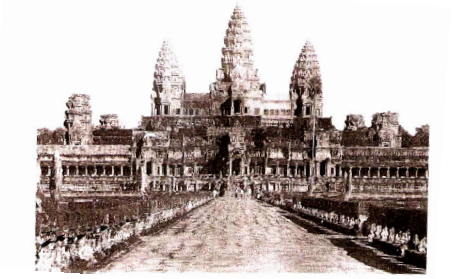
5. The Jantar Mantars, present even to-day at Ujjainī, Delhi, Varanasī, Mathurā and Jaipur and the various instruments like Transit Instrument, Sun-Dial, Rām Yantra etc. constructed there, proves our ancestor's knowledge in astronomy.

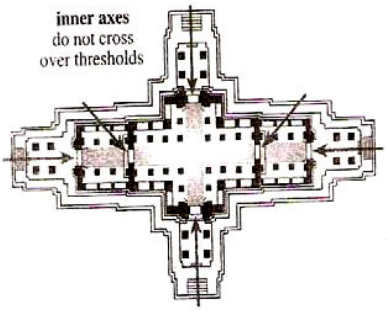
6. ANKGOR WAT OF CAMBODIA

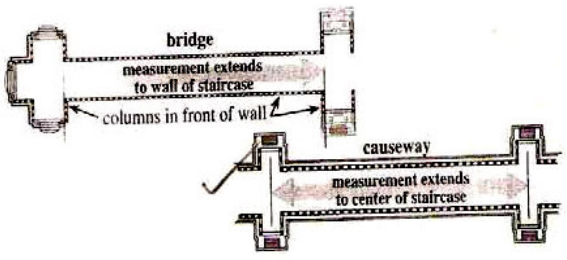
When the units of measurements were changed from meters to cubits, the measurements and meaning of the temple become clearly understandable and the temple demonstrates the ways through which the history of the king, cosmology, astronomy, the calendar and the realm of Gods were all interrelated. All information obtained from inscriptions on culture and architecture of Angkor Wat become suddenly manifest in the temple itself. Both northern and southern corridors of the third gallery are 202**.**14 meters long and the eastern and western corridors are 114**.**22 and 114**.**24 meters respectively. Why and how the circumference was constructed in a remarkably accurate manner? The answer lies in understanding the basic. If we alter the unit of measurement from meters to cubits it will show the answer. Cubit is a length from elbow to outstretched fingertips. Cubits and related units were inherited in Cambodia from Bhārat. Might be the King

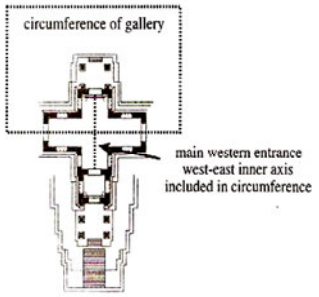
Sūryavarman 2's (Paramaviṣṇuloka, Khmer Empire, 1113 C.E. to 1145-1150 C.E., constructed in his reign) cubit used. One cubit will be about 0.43545 meters. North south axis in the sanctuary is of 13.41 cubits and 13.41 cubits is a basic module in the second gallery, devoted to Brahma. Ankgor Wat is situated 13.43 degrees of Northern Latitude. Thus, the measurements are based on the local latitude and it proves that the temple sthapathy knew astronomy very well. If we estimate the longitude of Ankgor Wat in relation to Ujjainī Lańka Longitude, it may yield better results. Ujjainī Lańka is the prime Meridian in ancient days (0° Logitude). It is 75°46´38´´ and Ankgor Wat is103° 52´ of Greenwich. Hence Ankgor Wat is 28° 5´ 22 ´´ East of Ujjainī Lańka Meridian.

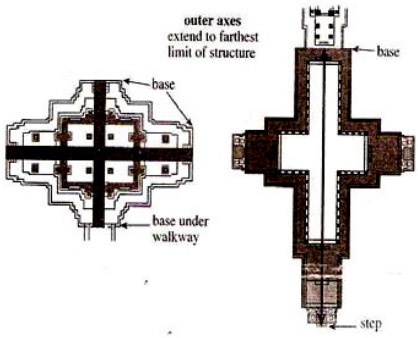
On measuring, we should follow how and in what manner it was constructed, like 1. The outer axial measurements should extend the farthest physical point of the structure, 2. The inner axes should extend from doorway to doorway only and not to cross the thresholds, 3. Raised surface ledges to be included, 4. In bridge and cause way, measurements should extend to wall of staircase and centre of staircase, 5. Balustrades are the boundary of measurements along the causeway, 6. Paths of circumambulations should be included in measurements, 7. The central space also should be included, 8. The circumference of each of the four enclosures is determined by a line along the centre of the circumference corridors. Assess it with constructor's scale and ways and not with the so called 'modern methods' which will not yield results exactly. **We should view the ancient structures with the eyes and mind of the constructors and not with our own.** (Ref. with thanks to 'Angkor Wat**:** Time, Space and Kinship' by Eleanor Mannikka, University of Hawaii Press).

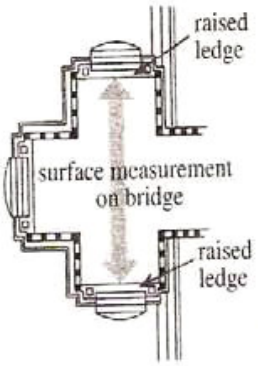


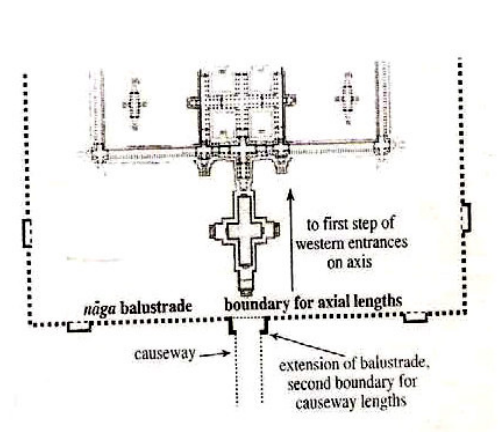


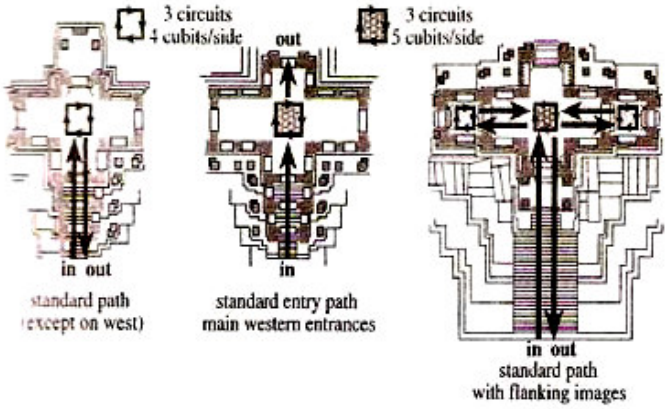












Thus, when we understand and follow the methods and means of the constructors, then only we can understand the basic aspects and the secrecy of the construction correctly, otherwise we will be misled to wrong conclusions. This is the very needed lesson Ankgor Wat teaches us.

7. Dates at which the rays of Sun fall on Śivalińga at various temples

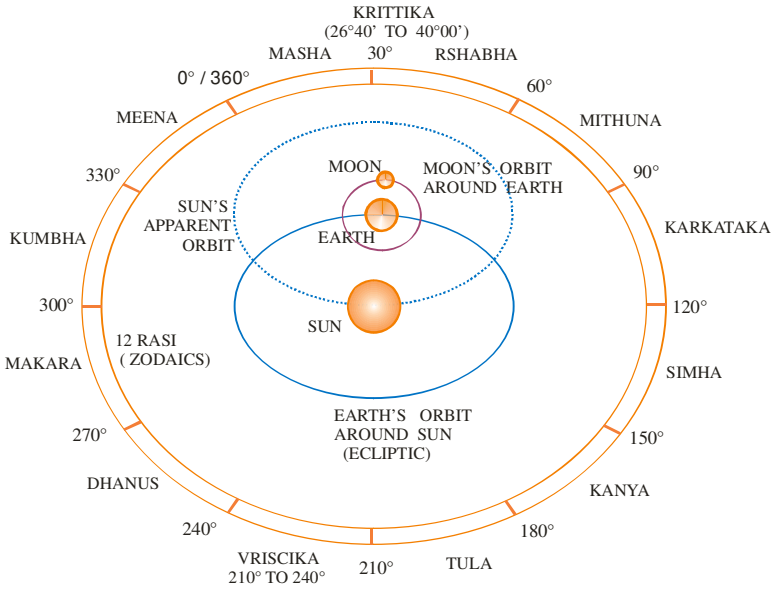
This shows that our ancestors knew astronomy well and with that sound knowledge and wisdom, they have constructed temples in a very scientific way. In the following, the dates and the names of the temples are given, where the Sun rays and or Moon rays are falling on the Main Deity, at a particular time and date in every year.

1. Tamil New Year Day, Chitrai 1 (Souramāna) - Kāṭṭūr Chennai and Śankaran Koil, Thirunelveli (ŚańkaraNārayaṉar, Gomathiamman) on Gomathiamman, 2. Chitrai 2,3,4 - Kālnaṭṭampuliyūr Thiruchirapalli, 3. Chitrai 7 to 18 - Chembaṉār Svarṉapurīśvarar, 4. Chitrai 11,12,13 - Kumbakoṉam Nageśvarar, 5. Chitrai 13,14 - Thiruvāsi, 6. Chitrai 13,14,15 - Thiruchoṭruthurai 7. Chitrai 18,19,20,21 - Paṭṭīśvaram Srī Dhenupurīśvarar, 8. Ādi 1,2,3,4,5 - Thiruneḍunkulathūr Chennai, **9. Āvaṉi 19,20,21, Māsi 19,20,21 -** Thirunaraiyur, **10. Puraṭṭāsi 7,8,9, Paṅguni 7,8,9 -**

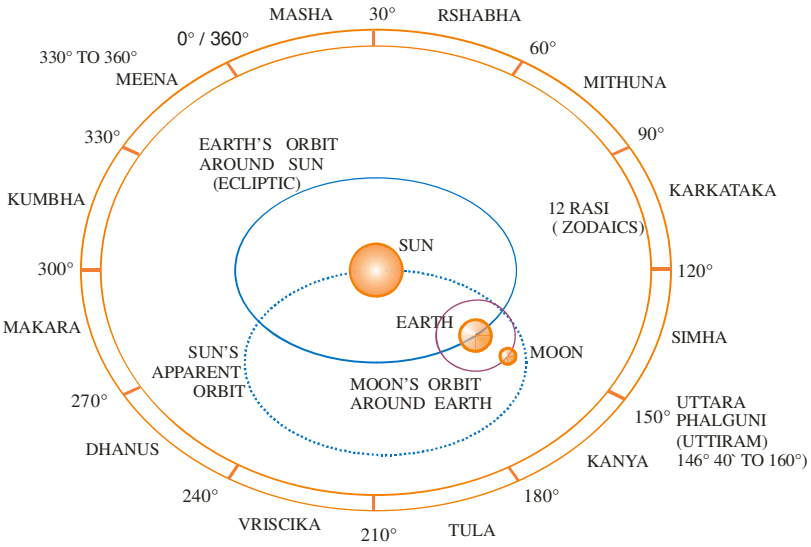
Thirupaiñjīli**, 11. Puraṭṭāsi 8, Pańguni 8 -** Thiruppāṭrurai, 12. Thai Rathasaptami - Kañchipuram Ekāmbaranāthar and Thirucheńkoḍu Erode, 13. Thai Amāvasyai for 1 week - Thirunelveli Srī Nelliayappar, 14. Māsi Śivarātri - Thirumurukanpūṉḍi Avinaśi, 15.Māsi 13,14,15 - Thirucherai, 16. Māsi 18 - Srī ARUṈĀCHALEŚVARAR, 17. Māsi 24,25,26 - Thirukarukāvūr, 18. Māsi 30, for 1 week - Nannilam, 19. Māsi 8,9,10 - Evening Time from 5-30 PM onwards first on Nandiyam Perumān, then at the footstep of Karuvarai (Sanctum Sanctorum), then at the base, middle part and then upper part of Śivalińga, (2 minutes at each part) Thāramańgalam Salem, 20. Pańguni 1,2,3 - Mānthurai, 21. Pańguni 13,14,15 - Thiruvedikudi, 22. Pańguni 26,27,28 - SrīMakuḍeśvarar ThirupāṉḍiKoḍumuḍi Erode and 23. On Equinoctial days - **Modherā (DharmaAraṉya),** Gujarath 102 Kms from Karṉāvati, on the bank of Puṣpavathi River. The temple was constructed during the rule of King Beemdev of Solańki Kingdom, in 1026 C.E. The Light Rays of the Sun fall on God Sūrya (the Main Diety) in the mornings. Sthalapurāṉa says Srī Rāma with Seetha Mātha on return to Ayodhya, after victory at Lańka worshiped here, on the advice of Ṟṣi Vasiṣṭha. In Thirunaraiyūr, Thirupaiñjīli and Thiruppāṭrurai, the temples are constructed in a very special manner, so that the rays of the Sun, worship Śivalińga both during Uttarāyaṉa and Dakṣināyana transits of the Sun, as shown by the dates mentioned above, which are exactly six months apart.

The most interesting will be the temple at Thirunāgeśvaram, near Kumbakoṉam. Here we worship Srī Nāganāthasvāmy (Seṉbaga Āraṉyeśvarar) and Piraiyaṉivānnuthal Umayāmbikai (Ardhacandrabimba Gujāmbikā). On Kārthikai Month Pourṉami (mostly the star of the day is Kṟttikā), at night 8 to 9 PM, the Light Rays of Moon will fall at the feet of Piraiyaṉivānnuthal Umayāmbikai. Chandra is said to perform Pūja and worship Piraiyaṉivānnuthal Umayāmbikai on Kārthikai Pourṉami day. The following diagram shows that with respect to the Sun, the Earth and the Moon are in conjunction with the ecliptic star Kṟttikā. However, with Earth as the reference point, the Moon is in conjunction with the star Kṟttikā and the Sun, at Vṟścika Rāsi, is exactly 180 degrees apart from Moon, and thus it is a full moon day (Pourṉami). Since the Sun is at Vṟścika

Rāsi, it is Kārtikai month. This month is named as Kārtikai, because almost in all Kārtikai months of all years, the full Moon, which is 180 degree apart from the Sun at Vr̥ścika Rāsi, is in conjunction with the star Kr̥ttikā. In our Nation, all the months of the year are named in this way only, i.e. with astronomical basis only. This shows our ancestors' thorough astronomical knowledge. Here, on the Full moon day of Kārthikai month, the Moon rays worship the feet of Piraiyan̲ivānnuthal Umayāmbikai.

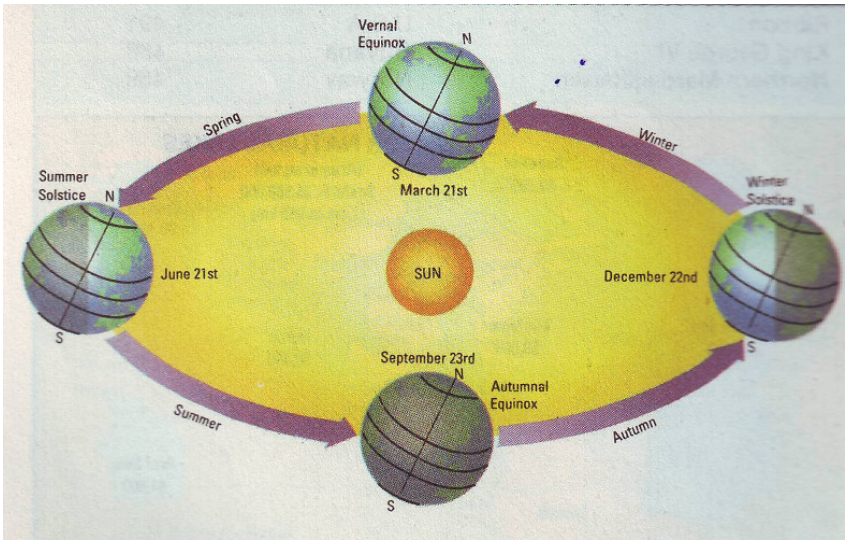


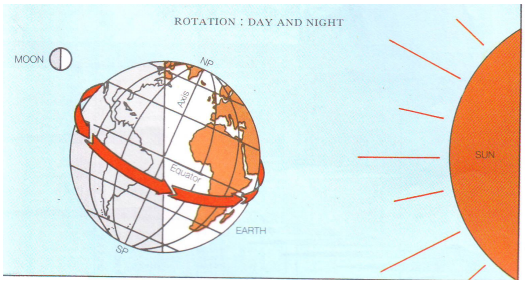
The same thing happens at Thiṅgalūr near Kumbakon̲am. Here we worship Kailāsanāthar and Periyanāyakiambāl. On Pourn̲ami tithi in Phālguna (Paṅguni) month (mostly the star of the day is

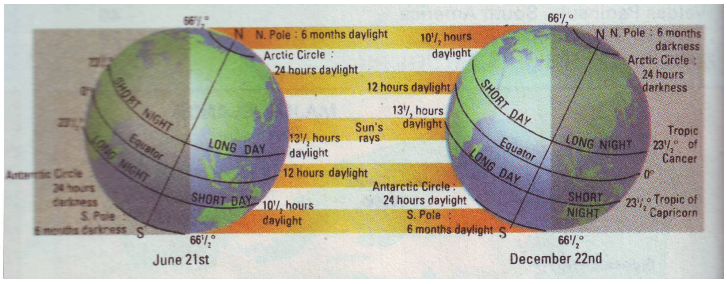


Uttara Phālgunī, Uttiram), at Sun Rise, the Light Rays of the Sun fall on Śivalińga and at Moon Rise, the Light Rays of the Moon fall on the Śivalińga. Here the Moon is in conjunction with the star Uttara Phālgunī (Uttiram) and is 180 degree apart from the Sun, on seen from the Earth. Hence it is a full moon day and the month is named as Phālguna (Pańguni). The Sun is at Mīna Rāsi with reference to Earth.

In these two temples, the rays of Moon worship God, on a particular month's full moon day only and not in all 12 full moon days of a year. This is because, the Earth's axis is inclined at 23° 27` to its ecliptic path around the Sun. Thus, the temples are constructed in a special manner,







that the rays can enter into the Sanctum Sanctorum at a particular angle, calculated according to the declination of the Sun and the Moon, on that particular month's full moon day. This is because, on revolving round the Sun in its Ecliptic, the part of the Earth that is in direct line with the Sun varies constantly, in accordance with Sun's declination. This is shown in the above figures. Here it is shown that the Sun Rays fall straight (90º) at the Equator of the Earth on March 21st and September 23rd (Sun's declination 0º), at the tropic of Cancer on June 21st (Sun's declination 23º 27`N) and at tropic of Capricorn on December 22nd (Sun's declination 23º 27`S). The Moon is

revolving round the Earth in almost in the same plane at which the Earth revolves round the Sun i.e. with a tilt of 5.145º only to the ecliptic. Thus, the plane of Earth, Moon and the Sun is almost same. Thus, the Earth's tilt towards Moon and Sun is unique to that month and date, that means, at that particular angle only, the Moon rays can enter into the Sanctum Sanctorum, in that month, on that particular date and not in other months and other dates. This particular angle is different for each month. Besides, due to inclination of the Earth, the various places of Earth are at various angles towards Sun and Moon, on any day of the year. In the same way, the angle at which the Sun is seen from a particular place varies on every day of the year, due to changing declination of the Sun. This is the basis of constructing a temple with the mechanism that enables the Sun rays to fall on the Deity, only on a particular date in a year.

COCLUSION

These evidences clearly show that astronomy is well developed in our Nation, that too, in the remotest antiquity. The movements of celestial bodies are calculated exactly with the expertise knowledge in astronomy, using the celestial co-ordinates, by our ancestors. This is essential in calculating the auspicious time in temple construction. In the same way, the co-ordinates of the Earth, the declination of the Sun and Śankusthapānam are very essential in fixing the directions exactly, at the place of temple construction. These things prove that our ancestors had a thorough knowledge in Astronomy, Civil Engineering, Architecture and Mathematics including Geometry and this knowledge had spread to the whole world. Thus, in our Nation, the temple construction and architecture are completely based on astronomy and is totally scientific. Hence, temple architecture and construction are Divinity, excellent art, but none the less science.
