Introduction to Indian Astronomy
Part 2

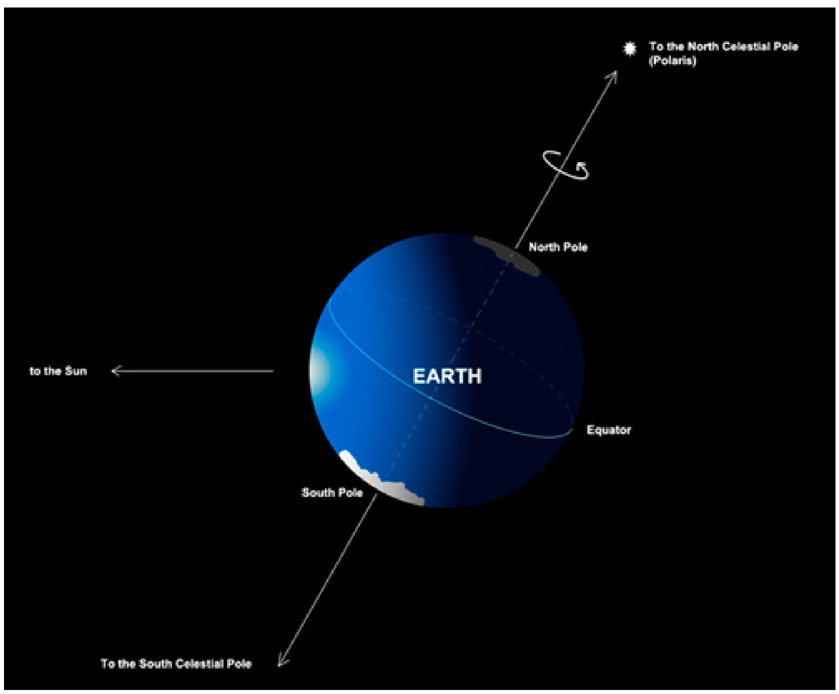
Adhikamāsa

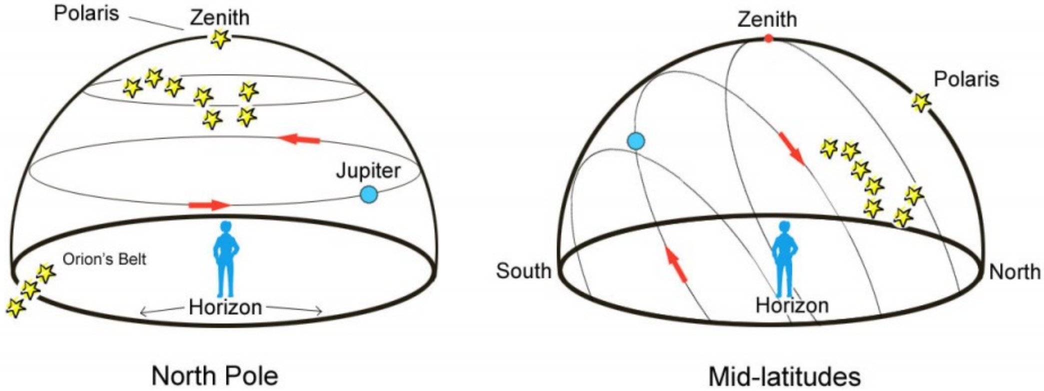
- We saw that the average duration between two new moons was 29.5 days
- Taking 12 lunar months for a year, we get 354 days
- But in a tropical solar year, there are 365.2425 days
- Hence, there are about 11 days more in the Solar year as compared to 12 lunar months
- In other words, if 12 lunar months is taken as one year; then there is an error of about 11 days
- This error builds over time and in 2.5 years it becomes about 28 days; when a full lunar month can be added for compensation
- Hence, in every 5 years, 2 extra months known as intercalary months or *adhikamāsa* is added to synchronize the motions of the Sun and the Moon.
- That is, in 5 solar years, there will be 62 lunar months
- In the earliest times, this 5 year period came to known as a *yuga* since the motions of the Sun and the Moon were approximately synchronized
- Still there will be some errors in this system, and it turns out once in about a 100 years, there will be a year with only 11 lunar months called *ūnamāsa*
- In certain regions, this *adhikamāsa* can be avoided if the month can be defined based on the Sun itself. This came to be known as the *Sauramāna* calendar.
- Here the ecliptic is divided into 12 equal parts, each known as a *rāśi* such as *Meṣa* (Airies), *Vṛṣabha* (Taurus), *Mithuna* (Gemini) etc. till *Mīna* (Pisces). The event that the Sun enters a particular *rāśi* is called *saṅkramaṇa* or *saṅkrānti*.
- A month may be then defined as one *saṅkrānti/saṅkramaṇa* to the next. For example, the first month *Meṣa* begins when the Sun enters the *Meṣa-rāśi* ends when the Sun enters *Vṛṣabha-rāśi*. In this reckoning, the duration of an year will be 20 minutes longer than the tropical year.
- Hence, in about 72 years, the event of *Meṣa-saṅkrānti* will slip one day forward according to the Gregorian calendar. For example, suppose in 2000 CE, *Meṣa-saṅkrānti* happened on 14th April exactly at Sunrise (6AM). Then in 2072 CE, *Meṣa-saṅkrānti* will happen on 15th April around Sunrise.
- The *Sauramāna* calendar is used in Bengal, Orissa, Tamil Nadu, Kerala and Coastal Parts of Karnataka. The *Chāndramāna* calendar is used in majority of Karnataka, Telangana, Andhra Pradesh, Uttar Pradesh, Bihar etc.

Pole Star and Precession of Equinoxes

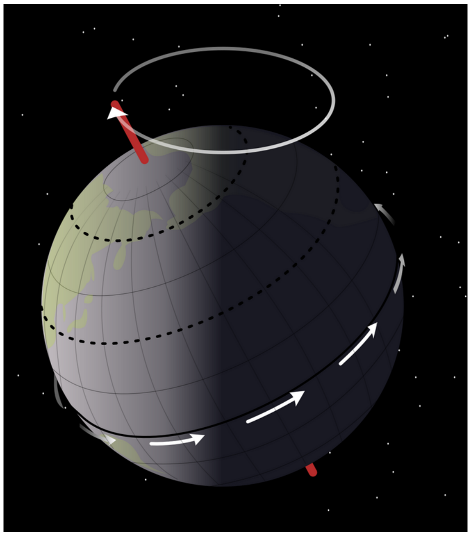
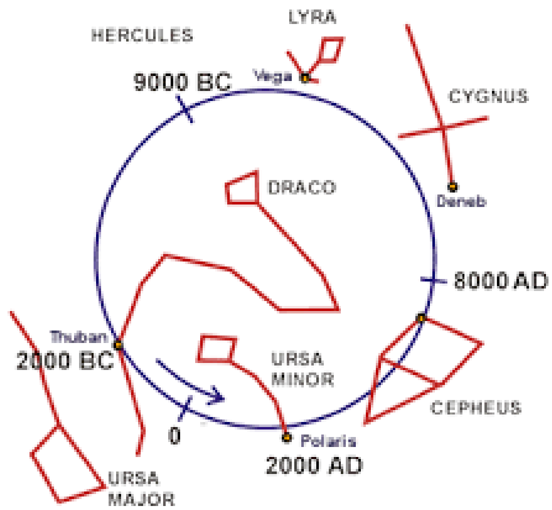
- Due to Earth's rotation on its axis, the Sun appears to rise in the East and set in the West

- Similarly all stars rise in the East and set in the West, except for one star: the pole star. Since majority of the Earth's landmass is in the Northern hemisphere, we will limit the discussion to only the pole star in the Northern hemisphere. That is the reason this pole star of the Northern hemisphere is sometimes called the North star.
- The pole star is located exactly in the direction of the axis of Earth's rotation. Hence, all stars appear to revolve around the pole star. That is the reason, the pole star is called *dhruva* (fixed) or sometimes also as *meru*
- At the equator, this pole star can be seen on the horizon. At the North pole, the pole star can be seen at zenith (90º from the horizon) or directly above one's head
- Hence, the angle the pole star makes with the horizon directly gives the latitutde of the place of the observer
- In addition to rotation on its axis, the Earth also wobbles (like a top) and as a result, the tip of the axis traces out a (imaginary) circle in space. It takes about 26,000 years to complete one full circle.
- If a star exists in the direction in which the axis points, then that star will be the pole star.





- The current pole star, Polaris, came to the pole position about 500 years ago. Earlier, Thuban was the pole star probably about 3000 years ago or so.
- There are instances in the *Mahābhārata* where it is observed that **even** the pole star is moving!

- This phenomenon of the movement of the pole star is called "precession of the equinoxes".
- This phenomenon has another interesting consequence: some stars may go out of the field of view from a particular location or some new star may suddenly become visible. Our ancients have passed on the memory of having seen a new star becoming visible in the night sky. This star was called *Agastya* and is known today by the name 'Canopus'. It is possible to calculate today as to when exactly the star *Agastya* may have become visible at say, *Kurukṣetra.*

Siderial year

- Earlier, we saw how the motion of the Moon was tracked with the help of *nakṣatra*s
- These *nakṣatra*s could be used to track the movement of the Sun too
- The time interval between two events of the Sun entering, say, *Aśvinī nakṣatra* is defined as a siderial year or *bhagaṇa* (*bha* = *nakṣatra*) in Sanskrit
- The siderial year on an average is 20 minutes longer than the tropical year due to precession of the equinoxes
- The average siderial year is 365.2563 days
- The celebration of *Makara-saṅkrānti* happens according to the siderial year, which is longer than the tropical year of 365.2425 days to which the Gregorian calendar is designed. Hence, *Makara-saṅkrānti* which usually falls on 14th/15th January will start slipping over time to 15th/16th January and so on.
- Winter solstice/*Uttarāyaṇa* usually occurs around December 21st which is pretty much fixed. We know that about two thousand years ago, *Makara-saṅkrānti* and

Uttarāyaṇa had coincided; which means then *Makara-saṅkrānti* was happening around December 21st.

- Just like the relative motion between Sun and Moon, there is a relative motion between the Sun and the Earth's axial tilt. Suppose the Sun is at point A today in star S. One year later, when the Sun returns to point A; the star S would have moved ahead slightly due to precession of the equinoxes. Therefore, the Sun takes an additional 20 minutes to align with star S.
- This difference of 20 minutes will grow to one day (24 hours) in about 72 years. With this rule of thumb, we can estimate the number of years ago when uttarāyaṇa (Dec 21) coincided with Makara-saṅkramaṇa (Jan 15). Since there is a gap of about 25 days, it means this alignment was there (25 X 72 =) 1800 years ago.

Imagery of Śrī Krishna's birth:

- It was mentioned earlier that *uttarāyaṇa* is day for *deva*s and *dakṣiṇāyana* is night. Hence, one human year (about 360 days) is one day for the *deva*s
- Similarly, ś*ukla-pakṣa* and *kṛṣṇa-pakṣa* (the bright fortnight and the dark fortnight) are day and night respectively for the *pitṛ*s. Hence, one human month is one day for the *pitṛ*s
- *Bhagavān Śrī Kṛṣṇa* was born on *Śrāvaṇa-māsa, Kṛṣṇa-pakṣa aṣṭamī* night in the *Rohiṇī nakṣatra. Śrāvaṇa* falls in the rainy season and in *dakṣiṇāyana.*
- Hence, *Śrī* Krishna's birth happens when it is night for the *deva*s, night for the *pitṛ*s and night for the *ṛṣi*s (humans) too. In addition, His birth happens in jail when His own uncle is waiting to kill him as soon as He takes birth. It is also raining heavily at the time, therefore making it difficult to even light a fire using a log of wood or any other fuel.
- Having being born in such a hopelessly gloomy dark situation, He goes on to show light to the entire world; enduring all what life throws at Him with a rise smile on His face without complaints about anything or anyone.
- *Śrī* Krishna's life and the said imagery is a source of hope and inspiration to humanity when faced with difficult and trying situations.

The concept of *Tretāgni*:

- The concept of *yajña* is central to the vedic tradition, where certain possessions (eg: ghee, twigs, leaves etc) of a person is voluntarily given up and offered to *agni* by symbolically offering it to at a fire altar
- Every householder initiated in the vedic *yajña* was obliged to offer oblations to the *deva*s, *pitṛ*s and *ṛṣi*s by constructing different altars for the same and igniting sacred fire in each of them. The three sacred fires were respectively called *āhavanīya-agni, dakṣiṇa-agni* and *gārhapatnya-agni*; and the three altars where

they were to be positioned were respectively square, semicircular and circular in shape. An additional constraint is that the area of the three altars have to be the same.

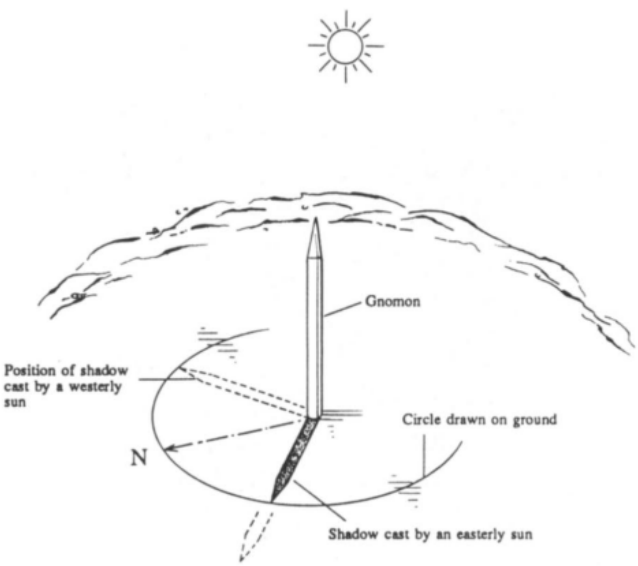
- The square altar for *āhavanīya* has to face to the East, the semicircular altar for *dakṣiṇa* to face South and the circular altar for *gārhapatnya* to face the West.

- In the center of these altars, another called *darśapūrṇa-māsa-vedi* or just *vedi* for short is to be made, which resembles a trapezium. This *vedi* is meant to be a place-holder for the *samidh* to be used in the oblations.
- In the most ancient times, *agni-cayana* (generated of sacred fire for *yajña*) was done by rubbing two *araṇi*s (logs of wood). Later on, for the sake of convenience, *gārhapatyna-agni* was always kept burning by offering timely oblations and whenever fire was required for oblations in the other altars or for cooking, it was sourced from the *gārhapatnya-agni.* Now-a-days, when a handful of people are following the *tretāgni upāsanā*, the memory of always having the *gārhapatnya* lighted is continued by lighting *dīpa*, diya etc on the threshold of homes or in *pūjā*-rooms.

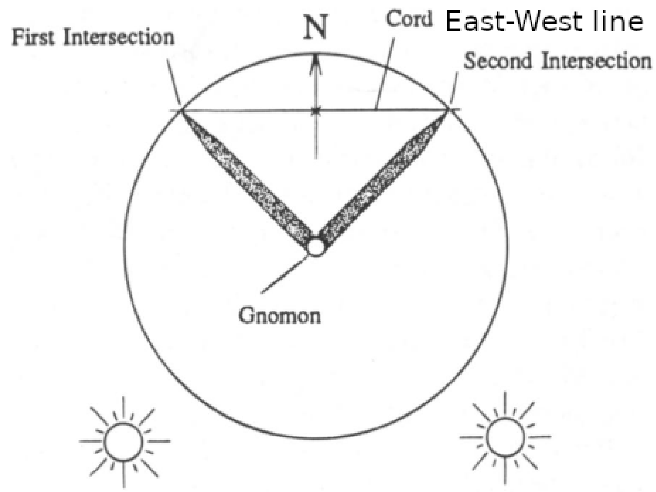
Determination of True East:

- The construction of the above altars necessitates the knowledge of the East direction
- The Sun rises in the East only approximately. The Sun does not rise at the same point everyday, but slowly drifts Northwards for six months and drifts Southwards for the other six months.
- Given the situation, our ancients came up with a simple and ingenous method of determining true East. The only pre-requisite is a level-field.

- A *śaṅku* (gnonom) is placed on a level field and a circle is drawn on the ground around the *śaṅku*. In the morning, the shadow of the gnomon intersects the circle; and that point of intersection is noted. Similarly, the point of intersection of the gnomon's shadow with circle is noted in the evening before sunset. The line joining the two marked points gives the East-West line; which is obtained as a chord of the circle drawn on the ground.



Indian circle method of finding north.



Method of using a cord to find the center of both intersecting points.