Indian Astronomy
through
Observations
from
Ancient Periods

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Outline of the talk

Topic	Info
	Lecture 1 (~15 slides in ~60 minutes)
Objects	Sun, Moon, Stars, Nakṣatras, Grahas(planets), etc
Sun's Rhythms	Ahorātrā(day), Ayana, Ṛtu(seasons), Samvatsara(year)
Rhythms of Nakṣatras and Stars	Ecliptic , Ecliptic Stars, Fixed Dhruva and the Slow Drift of Dhruva
Stellarium on Phone and PC	Observing the sky digitally

Topic	Info
	Lecture 2 (~15 slides in ~60 minutes)
Moon's Rhythms	Tithi, Pakṣa(fortnight), Māsa(month), Lunar Eclipse
Rhythms of Grahas	Visibility, Vakra(Retrograde), Prograde,
Eclipse and their Rhythms	Solar, Lunar
Calendar Systems	Lunar, Solar, Luni-Solar

What the Ancients Observed

पृथिवि	**Earth**	Where we are firmly grounded
		Contains rivers, mountains, plants, animals, people etc
आकाशः / द्यौः	**Sky**	the *sun* dominates during daytime, creating *dawn*, *dusk*, *seasons*
		the *moon* waxes and wanes in cycles night over night creating *phases*
		the *stars* emerge in the night forming *recognizable patterns*
अन्तरिक्षः	**Space-in-between**	the *clouds* exists bringing *rains*
		the *meteors* shower through occasionally bringing *disasters*

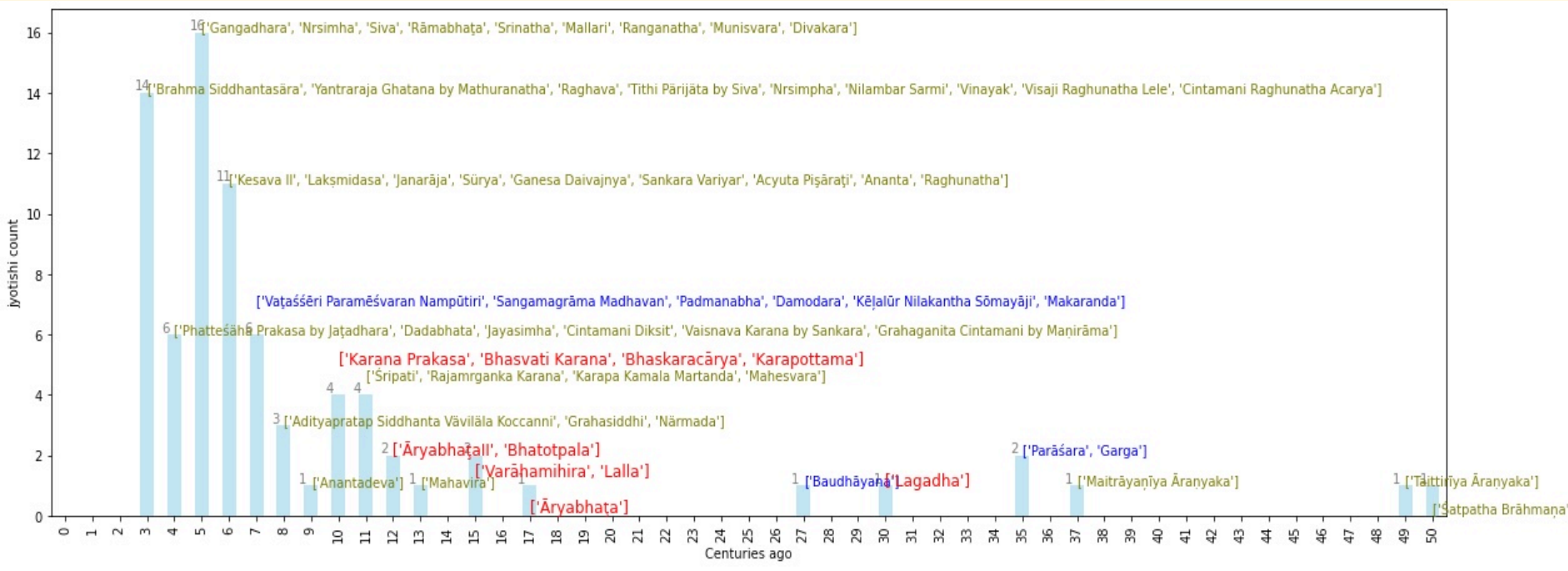
Astronomy **is a result of these observations and ponderings, started by the ancients and continually refined since.**

Purpose of these Observations

1. Pursue *curiosity*
2. Answer *questions* like
    1. Where will the sun rise tomorrow
    2. What will be the moon's phase tomorrow
    3. How many days hence is the next full moon
    4. How many days to the next rainy period
    5. When to sow seeds
    6. What is my birth nakshatra
    7. How does my birth nakshatra affect me
    8. How will the faded sun/moon impact the ruler/people
    9. When, what and whom to offer to adduce desired outcome

The greens need observation and calculation – *Astronomy*
The blues need additional interpretation – *Astrology*

A long tradition of Jyotishi-s



- **Jyotishi-s** are the Indian astronomers
- Some are very famous like *Aryabhata, Varahamihira, Brahmagupta, Bhaskara I, II etc*
- Others are less known like *Lalla, Bhattotpala, etc*
- This academic tradition faded about three centuries ago
- Interest is now being revived

Sun's rhythms - ayanas, ṛtus, nakṣatras, drift of ṛtus

Few Sun names - various qualities

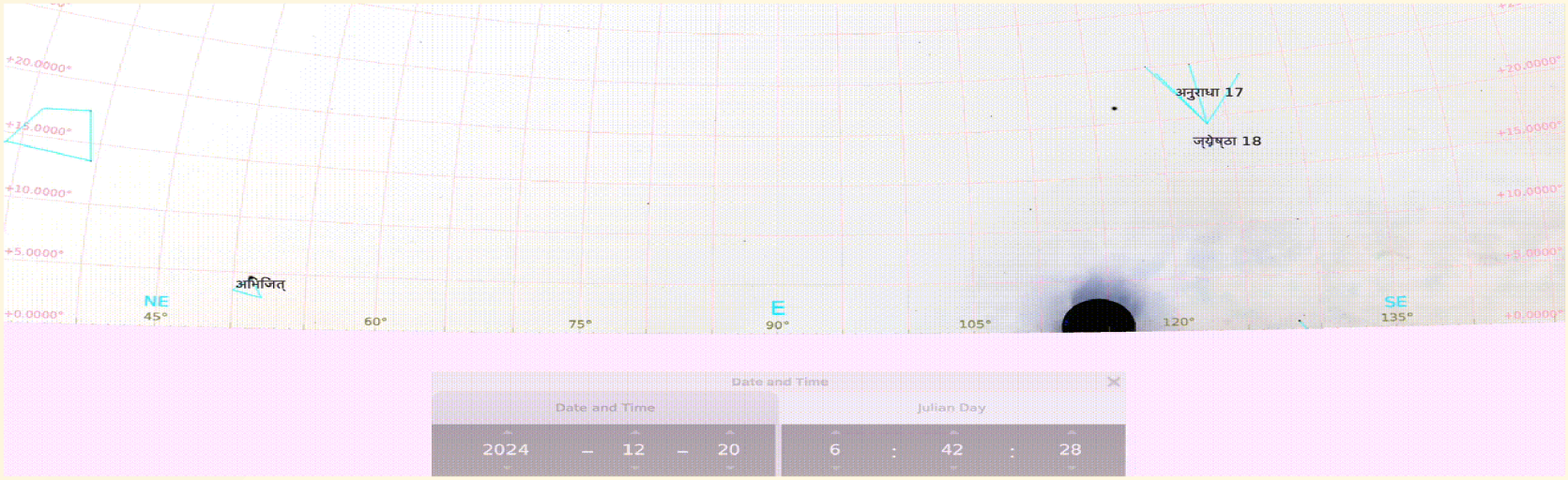
(some qualities observed, others inferred)

सूरः	*सूर्यः*	अर्यमा	*आदित्यः*	द्वादशात्मा
दिवाकरः	भास्करः	अहस्करः	ब्रध्नः	*प्रभाकरः*
विभाकरः	भास्वान्	विवस्वान्	सप्ताश्वः	*हरिदश्वः*
उष्णरश्मि	विकर्तनः	अर्कः	मार्तण्डः	मिहिरः
अरुणः	पूषः	*द्युमणिः*	तरणिः	मित्रः
चित्रभानुः	विरोचनः	विभावसुः	*ग्रहपतिः*	त्विषाम्पतिः
अहर्पतिः	भानुः	हंसः	*सहस्त्रांशुः*	तपनः
सवितृ	*रविः*	पद्माक्षः	तेजसांराशिः	*छायानाथः*
तमिस्त्रहन्	कर्मसाक्षी	*जगच्चक्षुः*	लोकबन्धुः	त्रयीतनुः
प्रद्योतनः	दिनमणिः	खद्योतः	लोकबान्धवः	ज्योतिष्मान्

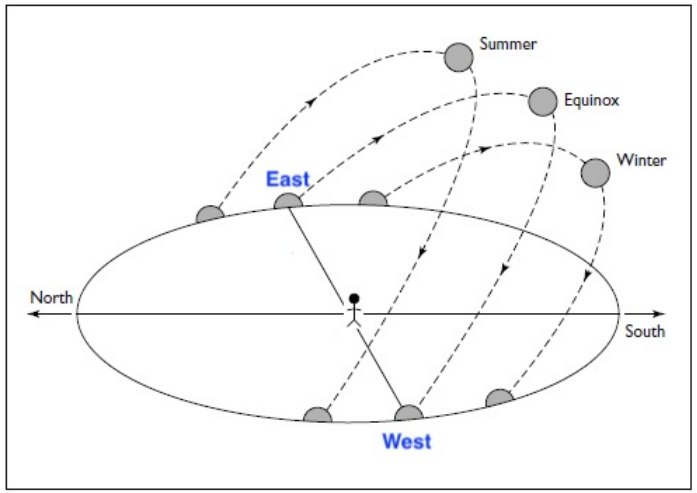
Observing the Sun's rhythmns

The **Sun** rises in the ~~*east*~~ **eastern horizon** and sets in the ~~*west*~~ **western horizon**

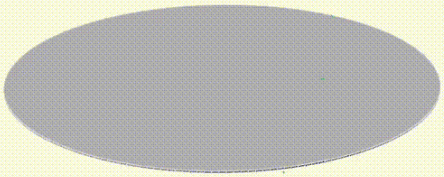
Season	Sunrise	Sunset
End-Summer	**north**-eastern horizon	**north**-western horizon
Mid-Spring/Autumn	**exact** east	**exact** west
Start-Winter	**south**-eastern horizon	**south**-western horizon



Annual Sunpath



- Video of ~2 minutes shows
- Sun's daily path for few evenly spaced days through the year
- The contrast between the summer and winter paths can be seen
- The contrast between the Bangalore and Kurukshetra paths can be seen



A Clock with more features - The Celestial Clock

- The sky is a hemisphere above us
- Stars are painted on the sky
- A band of stars around the east-west arc is the ecliptic
- The ecliptic can be thought of as the dial of a clock
- The stars on the ecliptic are the nakṣatra-s - much like the numbers on a clock
- The sun, moon and gruhas moves along the ecliptic - like hand tips on a clock

Alarm Clock	Celestial Clock
Dial	**Ecliptic**
Numbers	**Nakṣatra-s**
Hands	Sun, Moon, Gruhas
Slow Hour Hand	**Sun** Annual run clockwise
Fast Minute Hand	**Moon** Monthly run clockwise Cycling through it phase about every month
~ no equivalent ~	**Gruhas** travelling different speeds going anticlockwise sometimes going invisible sometimes
~ no equivalent ~	**Precession** The dial itself rotates anticlockwise very very slowly

Sun and Nakṣatras

We noted that each of the 366 sunrises occurs at different points on the eastern horizon due to the sun's swing. In addition, the stars that are visible just prior to each sunrise at the sunrise point also change. The stars that are visible just prior to sunrise are said to belong to the solar nakṣatra of that day.

A nakṣatra is a span of time of about 14 days for the sun, and contains the stars that are visible at sunrise in its time span. There are 27 such equal nakṣatra spans in a 366 day cycle.

Each of the 27 nakṣtra while of equal time span contains varying counts of stars - between 1 and 6 - totaling 83 stars. *A nakṣatra is therefore a span of space in the sky as well.*

The *27 nakṣatras* are named in a fixed cyclical order. The current order starting from Aśvinī along with their star count listed below, is an inherited order from around 1500 years ago. The order of the nakṣatra begins with Kṛttikā and ends with Bharanī in more ancient texts.

Aśvinī 3	Bharaṇī 3	Kṛttikā 6	Rohiṇī 5	Mṛgaśiras 3	Ārdrā 1	Punarvasu 2	Puṣya 1	Aśleṣā 6
Maghā 6	Pūrva Phalgunī 2	Uttara Phalgunī 2	Hasta 5	Citrā 1	Svātī 1	Viśākhā 2	Anurādhā 4	Jyeṣṭhā 3
Mūla 4	Pūrva Aṣāḍhā 4	Uttara Aṣāḍhā 4	Śravaṇa 3	Śraviṣṭhā 4	Śatabhiṣā 1	Pūrva Bhādrapadā 2	Uttara Bhādrapadā 2	Revatī 1

The choice of the first nakṣatra to start the cycle contains information on the epoch and the convention for the year start.

There are texts that associate specific nakṣatras with the ṛtus - seasonal naḳsatras . Such seasonal naḳsatras also contain vital information on the epoch of the text.

The Sun, Ṛtus and Nakṣatras

- Video of ~1½ minutes shows
- **Per year sun covers**
  - 2 ayanas
  - 6 ṛtu-s
  - 27 nakṣatra-s
  - Rtu-s & nakṣatra-s are associated
- **Over millenia**,
  - the nakṣatra-s drift slowly due to precession
  - This change is used to date the ancient texts

The Sun's Transit
through the
Seasons and Nakṣatras

Recap - Sun's rhythms

Every day

- Sunrises in the east *creating day*
- Sunsets in the west *ushering night*
- Sunrise and sunset *positions change* daily

Just before every sunrise

- One can observe *eastern horizon star changes*

Every ~14 days

- Sun moves through a *nakṣatra*

Every ~366 days

Sunrise completes one full swing along the eastern hor
izon

- A northern swing called *uttaryāṇa* for 183 sunrises
- A southern swing called *dakṣiṇāyana* for 183 sunrises

Start of uttaryāṇa/dakṣiṇāyana	solstice winter/summer
Mid of *uttaryāṇa*/dakṣiṇāyana	*equinox spring*/autumn

Sun cycles through

- *6 ṛtu-s* of 61 sunrises each vasanta, grīṣma, varṣā, śarat, hemanta, śiśira
- *27 nakṣatra-s* - the *same eastern horizon star* appears just before sunrise

Occasionally

- Sun goes partially or fully dark before recovering - *Eclipse*

Every 1000 years

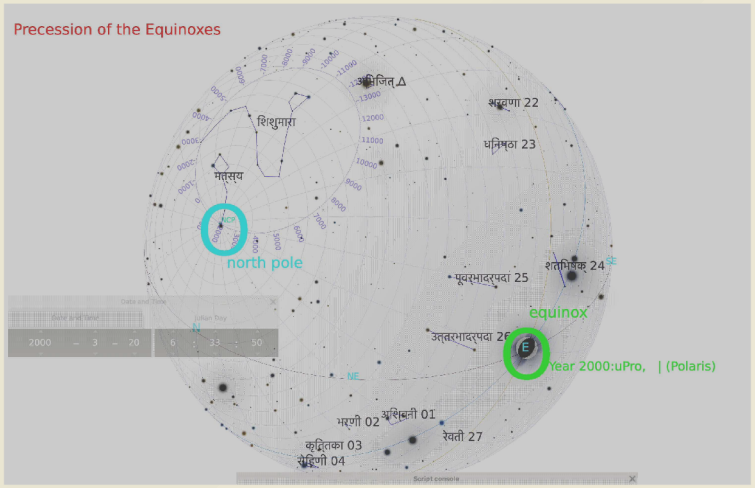
- The *spring equinox nakṣatra moves backward by one naḳsatra* due to precession
- i.e. **seasons move backward by one naḳsatra**

Effect of precession over millennia

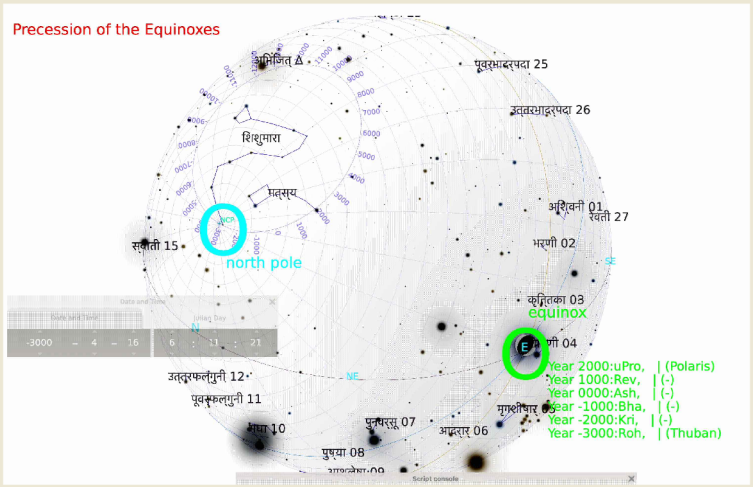
- About every *1000 years* the start of *seasons move backward by one naḳsatra*. **In addition the precession causes the pole star to change.**
- The following table/pictures shows the start of the spring equinox seasonal naḳsatra and the pole star for the last 5000 years.

Epoch	Spring Equinox	Dakṣiṇāyana	Uttaryāṇa	Pole Star
Present	Uttara Bhādrapadā	Ārdrā	Mūla	Polaris
1000 years ago	Revatī	Punarvasu	Pūrva Aṣāḍhā	-
2000 years ago	Aśvinī	Puṣya	Uttara Aṣāḍhā	-
3000 years ago	Bharanī	Aśleṣā	Śravaṇa	-
4000 years ago	Kṛttikā	Maghā	Śraviṣṭhā	-
5000 years ago	Rohiṇī	Pūrva Phalgunī	Śatabhiṣā	Thuban

Present Day



5000 years ago



Recall questions

#	Question
1	What is an ayanā?
2	How many nakṣatra-s and seasons in one ayanā?
3	What is the duration of one ṛtu?
4	What is the most pleaseant ṛtu? Which among the four solstices/equinox is it associated with?
5	Solsitices means still-sun. Using swing in park/tree analogy, explain why it is so.
6	How many times does the sun rise in a year? How many are those are closest to true east?
7	What is a nakṣatra? Is it a time span or a space span? How many stars are there in a nakṣatra?
8	What is the current start order of the nakṣatra-s? What is the start order in more ancient texts?
9	What is the significance of the first nakṣatra in the cycle?
10	How is precession of the equinoxes used to date ancient texts?
11	List five names of the sun and their qualities.
12	What is the difference between astronomy and astrology as we understand it today?
13	What is the significance of the pole star in the sky?
14	What is your birth nakṣatra? What does it mean to you?
15	What is the significance of the ecliptic in the sky?
16	Name a few ancient astronomers and their contributions.

Stellarium on phone and/or PC
Observing the sky digitally

End of Lecture 1

Outline - Lecture 2

Topic	Info
	Lecture 2 (~7 slides in ~60 minutes)
Recap Lecture 1	
Moon's Rhythms	Tithi, Pakṣa(fortnight), Māsa(month)
Calendar Systems	Lunar, Solar, Luni-Solar
Hands on Stellarium	Observing the sky digitally
~~**Rhythms of Grahas**~~	~~Visibility, Vakra(Retrograde), Prograde,~~
~~**Eclipse and their Rhythms**~~	~~Solar, Lunar~~

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Moon and Sun - Hide and seek

Clock Analogy

The fast moon overtakes the slow sun every month much like a fast minute hand overtakes a slow hour hand every hour

	Thithi	Sun Moon Separation	Moon rise	Moon Overhead
🌑	**Amavāsya** is when the moon is closest to the sun	**0°** Together	with Sunrise	Mid noon
🌓	**Śukla Aṣṭamī** is when the moon is 90° from the sun	**90°**	6 hours after sunrise (mid noon)	around 6 pm
🌕	**Pūrnima** is when the moon is farthest from the sun	**180°** Opposite	with Sunset	Mid night
🌗	**Kṛṣṇa Aṣṭamī** is when the moon is 270° from the sun	**270°**	6 hours before sunrise (mid night)	around 6 am

	Starts	Ends	Contains	
Śukla Pakṣa	amāvāsya+1	pūrnima	15 Śukla tithis	Moon moving away from sun
Kṛṣṇa Pakṣa	pūrnima+1	amāvāsya	15 Kṛṣṇa tithis	Moon moving towards sun

15 Thithis *and their early names Nanda ... Pūrṇā*

नन्दा	भद्रा	जया	रिक्ता	पूर्णा
प्रथमा/प्रतिपदा	द्वितीया	तृतीया	चतुर्थी	पञ्चमी
षष्ठी	सप्तमी	अष्टमी	नवमी	दशमी
एकादशी	द्वादशी	त्रयोदशी	चतुर्दशी	पूर्णिमा/अमावास्या

Moon and Months

मासः மாதம் ತಿಂಗಳು month - all units of time from the word for moon

चन्द्रमासः	mean 29.5 days	From one pūrnima/amavāsya to the next	चैत्रः वैशाखः ज्येष्ठः आषाढः श्रावणः भाद्रपदः आश्विनः कार्तिकः मार्गशीर्षः पौषः माघः फाल्गुनः ಚೈತ್ರ ವೈಶಾಖ ಜ್ಯೇಷ್ಠ ಆಷಾಢ ಶ್ರಾವಣ ಭಾದ್ರಪದ ಆಶ್ವಯುಜ ಕಾರ್ತೀಕ ಮಾರ್ಗಶಿರ ಪುಷ್ಯ ಮಾಘ ಫಾಲ್ಗುಣ *Full Moon approximately near the nakṣatra that names the month*
स्तृमासः	mean 27.3 days	From one nakṣatra to the same	
सौरमासः	29 to 32 days	sun based	**मेषः** वृषभः मिथुनः कटकः सिंहः कन्याः तुला वृश्चिकः धनुः मकरः कुम्भः **मीनः** **சித்திரை** வைகாசி ஆனி ஆடி ஆவணி புரட்டாசி ஐப்பசி கார்த்திகை மார்கழி தை மாசி **பங்குனி** **മേടം** ഇടവം മിഥുനം കർക്കിടകം ചിങ്ങം കന്നി തുലാം വൃശ്ചികം ധനു മകരം കുംഭം **മീനം** **मधुः माधवः** शुक्रः शुचिः नभः नाभः इषः उर्जः सहः सहस्यः तपः तपस्यः

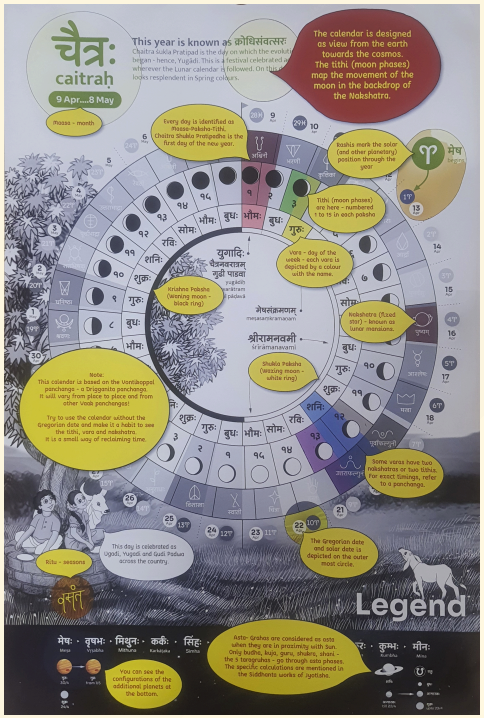
Panchāṅga - a Calendar System

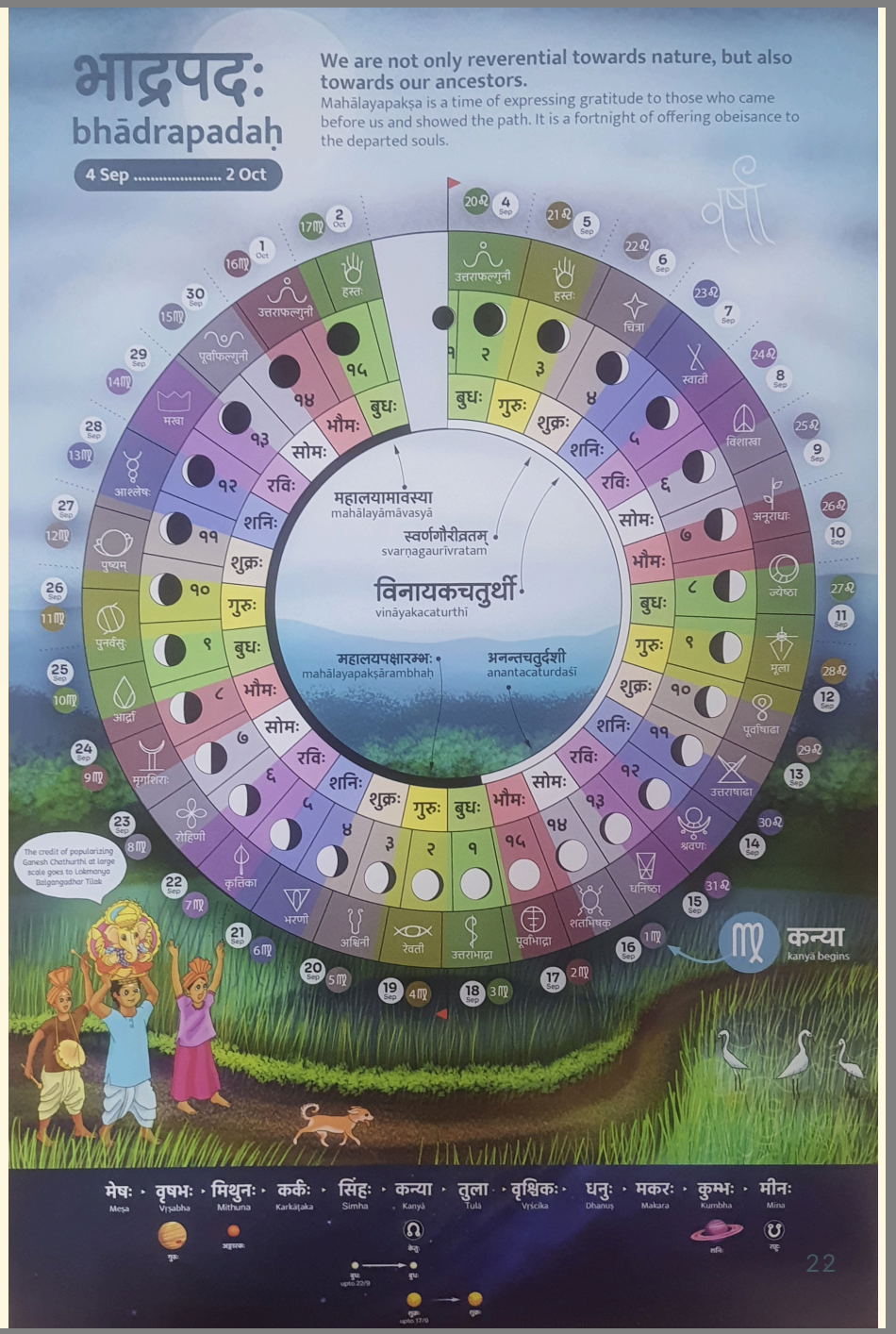
- Each **Sunrise** has an associated **Tithi, Vāra, Nakṣatra, Yoga, Karana**. These are the five limbs of the **Panchāṅga**.
- Each of these limbs are **either observed or compute/derived** from the positions of the Sun and Moon in the sky.
- **Panchāṅga** is a calendar system that is used to track time and events. It is also used to determine the auspicious and inauspicious times for various activities.
- This five limb system is **relatively modern (post अर्थशास्त्रः)** and used in various forms across India and South East Asia.

तिथिः	30	Moon Phase		Observable	**प्रथमा/प्रतिपदा** द्वितीया तृतीया चतुर्थी पञ्चमी षष्ठी सप्तमी अष्टमी नवमी दशमी एकादशी द्वादशी त्रयोदशी चतुर्दशी पूर्णिमा/अमावास्या
नक्षत्रम्	27	Moon's companion		Observable	**अश्विनी** भरणी कृत्तिका रोहिणी मृगशीर्ष आर्द्रा पुनर्वसु पुष्य आश्लेषा मघा पूर्वफल्गुनी उत्तरफल्गुनी हस्त चित्रा स्वाति विशाखा अनुराधा ज्येष्ठा मूल पूर्वाषाढा उत्तराषाढा श्रवण श्रविष्ठा शतभिषा पूर्वभाद्रपद उत्तरभाद्रपद रेवती
वारः	7	Sequence repeats every 7 sunrises	Lord of the day	Not observable	**रविवासरः** सोमवासरः मङ्गलवासरः बुधवासरः गुरुवासरः शुक्रवासरः शनिवासरः
योगः	27	Derived from Sun and Moon position	Used mainly in फलितम्	Not Observable	**विष्कुम्भः** प्रीतिः आयुष्मान् सौभाग्यः शोभनः अतिगण्डः सुकर्मा धृतिः शूलः गण्डः वृद्धिः ध्रुवः हर्षणः वज्रः विष्टिः सिद्धिः व्यतीपातः वरीयान् परिघः शिवः सिद्धः साध्यः शुभः शुक्लः ब्रह्मा इन्द्रः वैधृतिः
करणम्	11	Half of a tithi	Used mainly in फलितम्	Not Observable	**बवः** बालवः कौलवः तैतिलः गरः वणिजः विष्टि/भद्रा **शकुनि** चतुष्पाद् नागः किंस्तुघ्नः

A sample month

- Calendar by Dr Guha Vishwanathan MV
- 1947 शालिवाहनसंवत्सरः, 2024 Gregorian , 2081 विक्रमसंवत्सरः
- Notice the **Tithi, Vāra, Nakṣatra, Gregorian day** for each day
- Notice where each of these **start and end**
- Notice the **Pakṣa** and the **Māsa** for each day
- Find the **Sunrise and Sunset** markers for each day

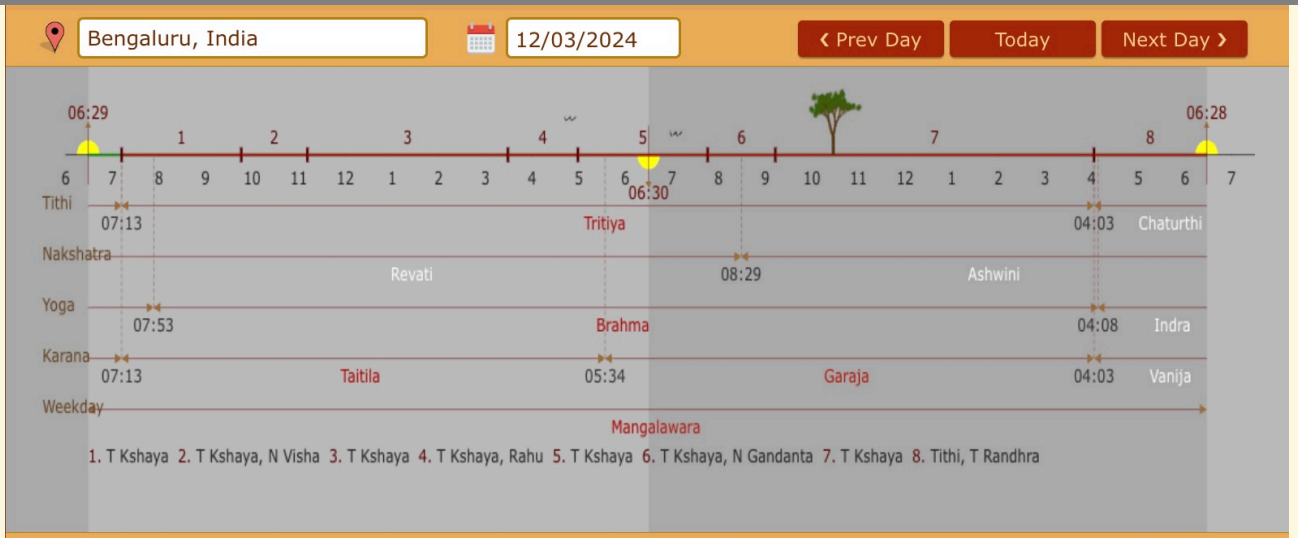




A sample day

(drigpanchang.com)

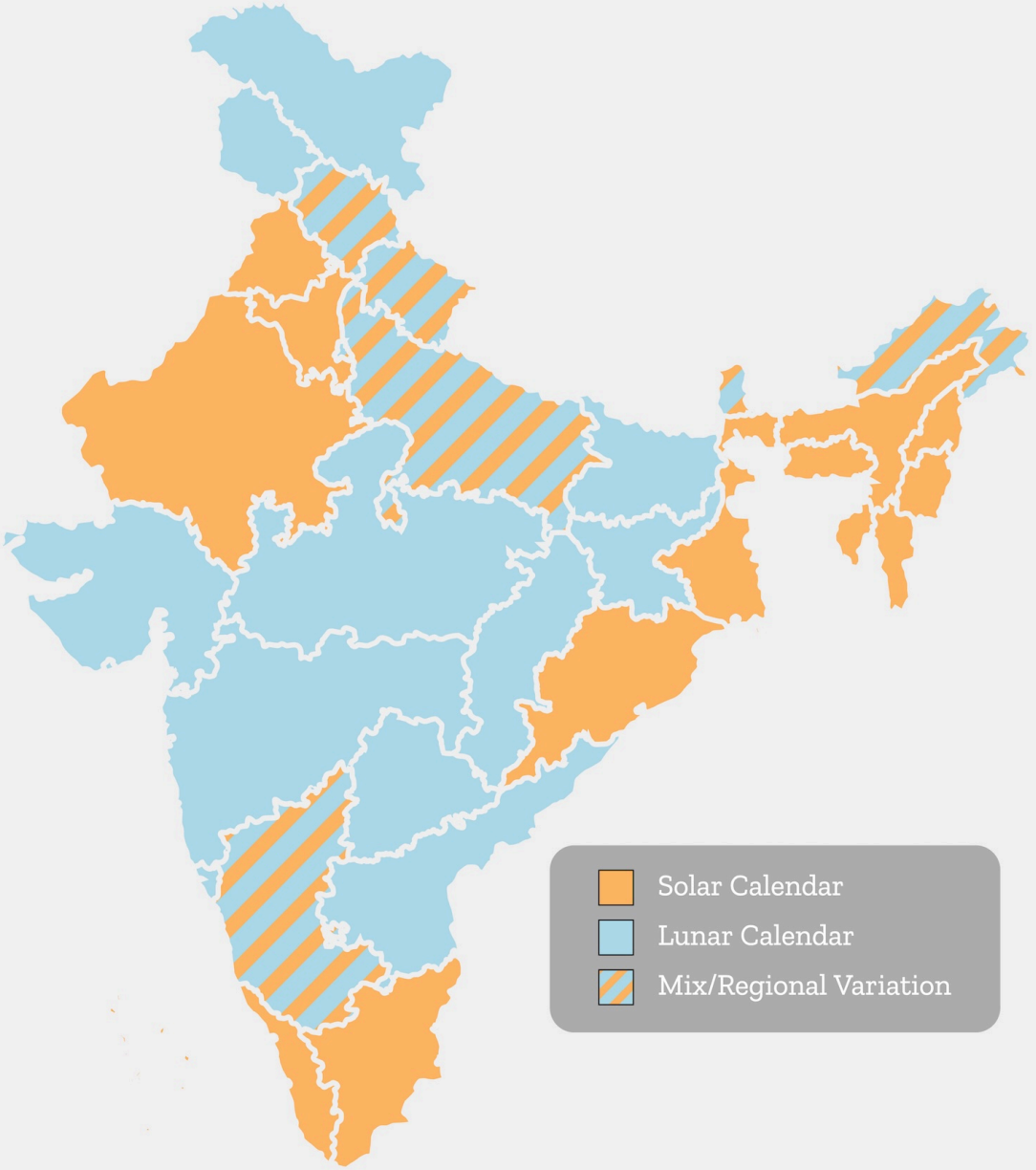
- Phalguna 22, 1945 Shaka - Mar/12/2024
- Notice the **Tithi, Vāra, Nakṣatra, Yoga, Karaṅa** for each day
- Notice this **Tithi** is trapped between two **Sunrises** . It a **kśaya tithi**
- Some thithis can consume two sunrises



Sunrise and Moonrise			
Sunrise	06:29 AM	Sunset	06:30 PM
Moonrise	07:53 AM	Moonset	08:35 PM
Panchang			
Tithi	Dwitiya upto 07:13 AM	Nakshatra	Revati upto 08:29 PM
	Tritiya upto 04:03 AM, Mar 13		Ashwini
	Chaturthi	Karana	Kaulava upto 07:13 AM
Yoga	Shukla upto 07:53 AM		Taitila upto 05:34 PM
	Brahma upto 04:08 AM, Mar 13		Garaja upto 04:03 AM, Mar 13
	Indra		Vanija
Weekday	Mangalawara		
Paksha	Shukla Paksha		
Lunar Month and Samvat			
Shaka Samvat	1945 Shobhakrit	Chandramasa	Phalguna - Purnimanta
Vikram Samvat	2080 Nala		Phalguna - Amanta
Gujarati Samvat	2080 Rakshasa		
Rashi and Nakshatra			
Moonsign	Meena upto 08:29 PM	Nakshatra Pada	Revati upto 09:43 AM
	Mesha		Revati upto 03:05 PM
Sunsign	Kumbha		Revati upto 08:29 PM

Calendar Systems in India

- **Luni-Solar** Both Sun and Moon are used to determine the year and month - **Panchāṅga**
- **Lunar** Only Moon is used to determine the year and month - **Islamic**
- **Solar** Only Sun is used to determine the year and month - **Gregorian**



New year in India

- **Mesha Sankranti** is the new year in many parts of India - **Solar Event**
- **Chaitra 1/Ugadi** is the new year in many parts of India - **Luni-Solar Event**
- **January 1** is the new year in many parts of India - **Gregorian/Solar Event**

Stellarium on phone and/or PC
Observing the sky digitally

- Locate the Sun using Stellarium now

- What was the sun rise time today?

- What is the nearest nakṣatra to the moon today?

- Locate the pole star in the sky in the day time and night time

Recall questions - Lecture 2

#	Question
1	What is a tithi?
2	What is a pakṣa?
3	What is a māsa? How many types are there.
4	**What is the difference between a lunar, solar and luni-solar calendar?**
5	**What is the difference between a panchāṅga and a calendar?**
6	What are the five āṅga of a panchāṅga?
7	Which of the five āṅga are observable and which are computed?
8	How many tithis are there in a māsa?
9	Using drigpanchang.com, locate your birth event. What is the tithi, vāra, nakṣatra, yoga and karaṇa ?
10	How many years, चन्द्रमासः and सृमासः in 1830 days to the nearest integer
11	Name 3 states following amanta , pūrṇimānta and saura māsa-s.
12	**What are rāka anumati kuhu and sinīvālī?**
13	Around what time can the moon be seen overhead during Rama-navamī and Krishna-aṣṭamī.
14	Discuss the various new year events in India

End of Lecture 2

Outline - Lecture 3

Topic	Info
Recap Lecture 2	
Moon's Rhythms	Tithi, Pakṣa(fortnight), Māsa(month)
Calendar Systems	Lunar, Solar, Luni-Solar
Hands on Stellarium	Observing the sky digitally
Lecture 3 (~7 slides in ~60 minutes)	
Rhythms of Grahas	Visibility, Vakra(Retrograde), Prograde
Eclipse and their Rhythms	Solar, Lunar

ग्रहाः Grahas

ग्रहः	From the धातु **ग्रह्**	to grasp, to seize, to hold

अथर्ववेदपरिशिष्टम्
(५२,११.४) कूटस्थेष्वप्रसन्नेषु स्थावरं परिहीयते । **आदित्य**श्चैव **शुक्र**श्च **लोहिताङ्ग**स्तथैव च ॥
(५२,११.५) **राहुः सोमः शनैश्चरो बृहस्पति बुधौ** तथा । ऐन्द्र आग्नेयो याम्यश्च नैर्ऋतो वारुणस्तथा ॥
(५२,१२.१) वायव्यश्चैव सौम्यश्च ब्राह्मश्चै**वाष्टमो** ग्रहः । **नवमश्**चैव विज्ञेयो **धूमकेतु**र्महाग्रहः ॥

श्रीविष्णुधर्मोत्तरे प्रथमखण्डे द्विसप्ततितमोऽध्याये
नामसंख्या बुधैर्ज्ञेया ग्रहगत्यनुसारतः ॥
तत्र **ताराग्रहाः पञ्च द्वौ च ज्ञेयौ महाग्रहौ** ॥ ७ ॥
उपग्रहौ च द्वौ ज्ञेयावेवं प्रोक्ता **नव ग्रहाः** ॥
भौमज्ञजीव**भृगु**जसौरास्ताराग्रहास्स्मृताः ॥ ८ ॥ **there 5 tārāgrahas here - but the text is not clear**
चन्द्रा-**दित्यौ** तथा राम विज्ञेयौ **द्वौ महाग्रहौ** ॥
उपग्रहौ च द्वौ ज्ञेयौ **राहुः केतुश्च** भार्गव ॥ ९ ॥

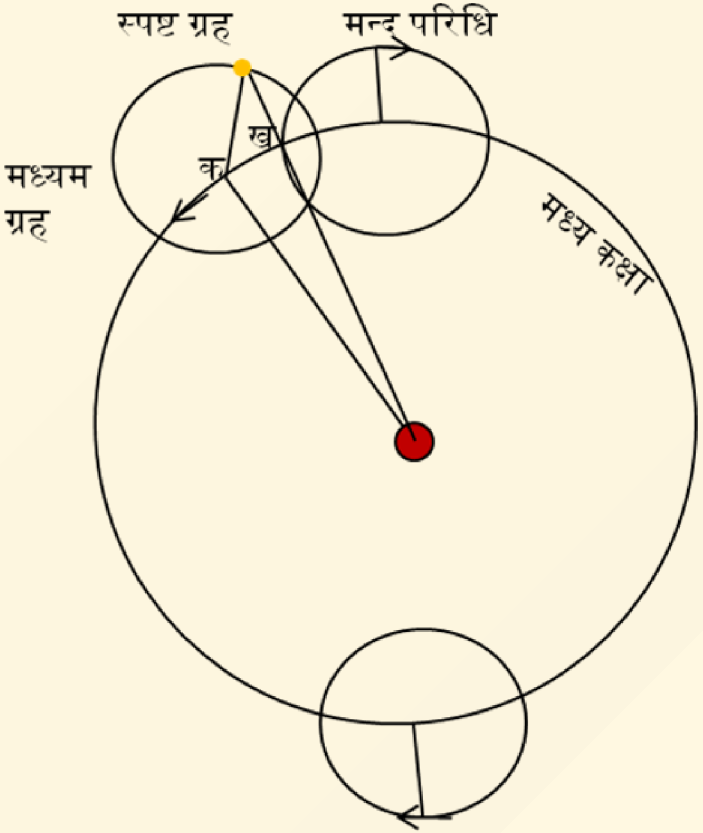
5 ताराग्रहः	Grasps the stars	मङ्गलः बुधः गुरुः शुक्रः शनिः
2 महाग्रहाः	The dominant ones	सूर्यः चन्द्रः
2 छायाग्रहः / उपग्रहः	Shadowy graspers	राहुः केतुः

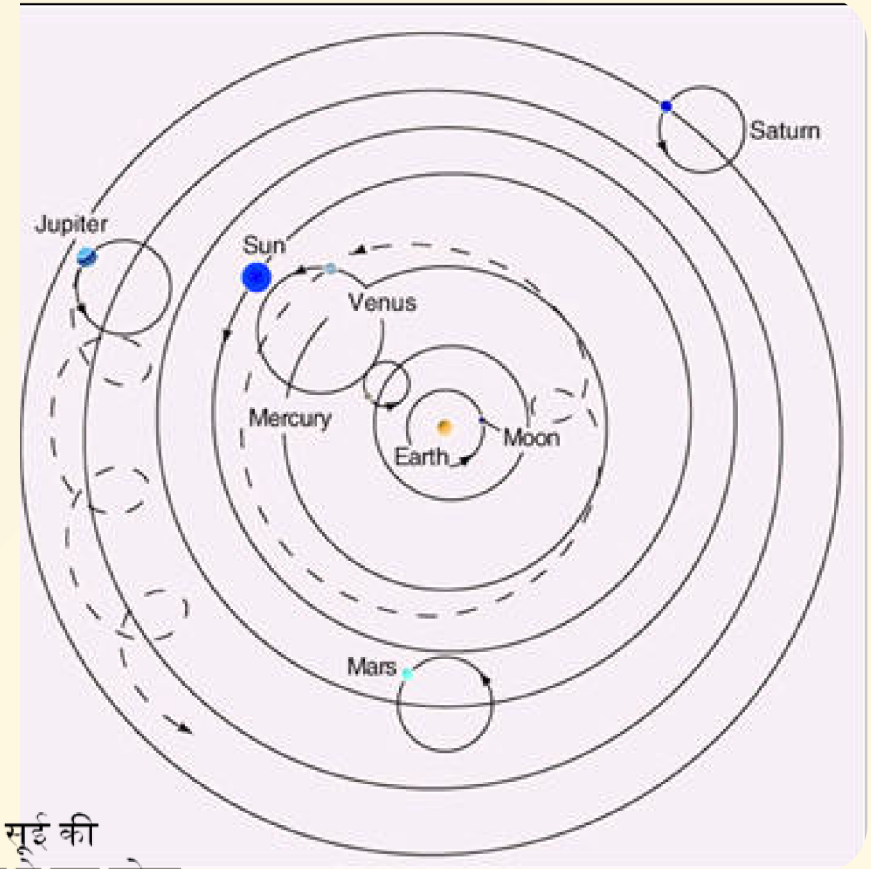
Grahas in Parāśaratāntram

ग्रहः		PT Info	Modern Info
सूर्यः	Sun	1 year Indicates Seasons	~1 year -
चन्द्रः	Moon	1 month Moon Horn's and taragrahas portends	~1 month -
मंगलः	Mars	Vakra paths described - zig-zag, hilt	paths can be observed
बुधः	Mercury	7 paths	7 visible windows per year
गुरुः	Jupiter	Moves 2¼ nakṣatras per year Rohiṇī occultation is bad omen	~12 years -
शुक्रः	Venus	Visibility: *east(↑270 ↓68) west(↑240 ↓13)* If seen all day invader trouble for cities/villages; Lots of connection to rainfall	*east(↑263 ↓50) west(↑263 ↓9)* - - -
शनिः	Saturn	30 years Invisible to about 30 days each year	~30 years Consistent with modern
राहुः	North Node	10 types *ग्रसना रोहणो पघ्रातो न्मर्दन निरोध परिलेहना पसव्य सव्या न्तर्मध्यतम उपप्लवा*श्च Six colors of lunar eclipse Lunar Eclipse every 6 months for 3.5 years	Can be Reasoned
केतुः	¿ǝpoN ɥʇuoS	*11classes 101comets अथैकादशजातय एकोत्तरशतकेतवो* भवन्तीति पराशरादीनां मतम् Detailed description of shape color periodicty and portend	Ketu is now considered to cause lunar eclipse. This is unfortunate. The tradition of comet study got lost

Movement of Gruhas in Āryabhaṭīya/Sūrya Siddhānta

Pictures sourced from
https://people.highline.edu/iglozman/classes/astronotes/media/retro_epicycle.jpg and
https://maghaa.com/wp-content/uploads/2018/05/Picture36.png



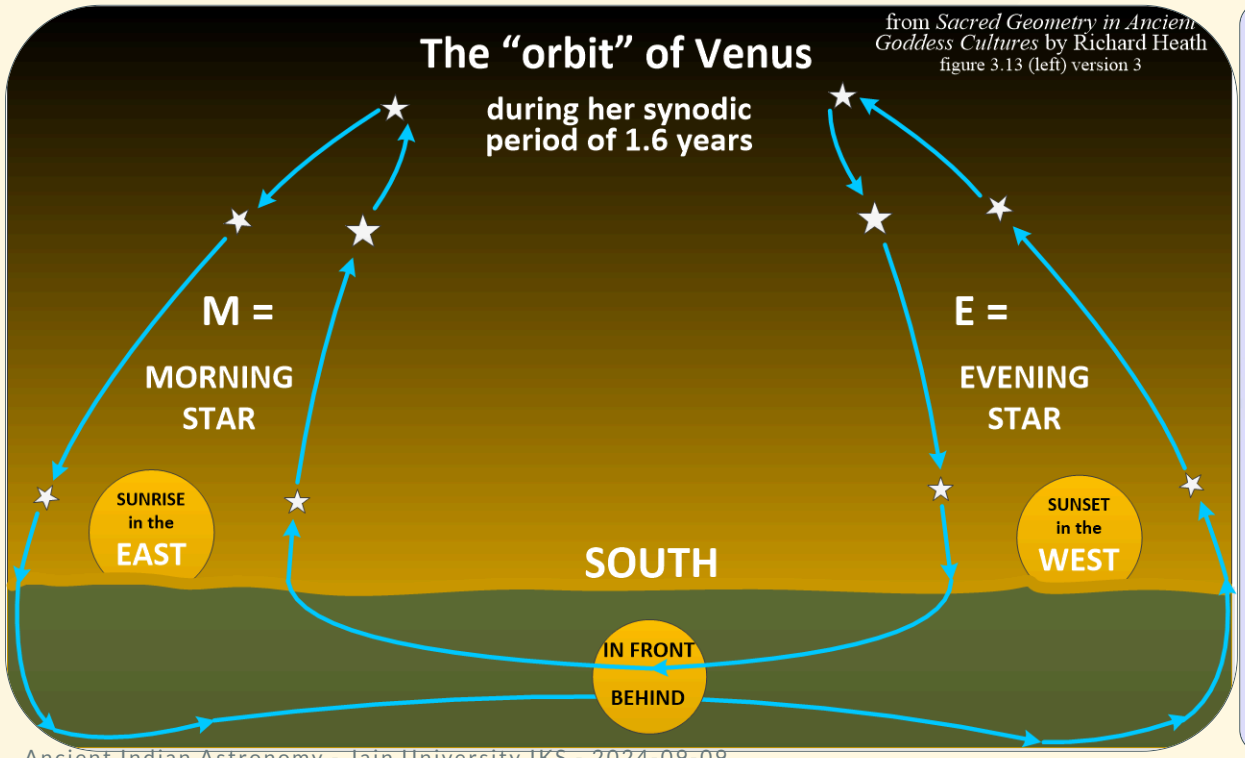


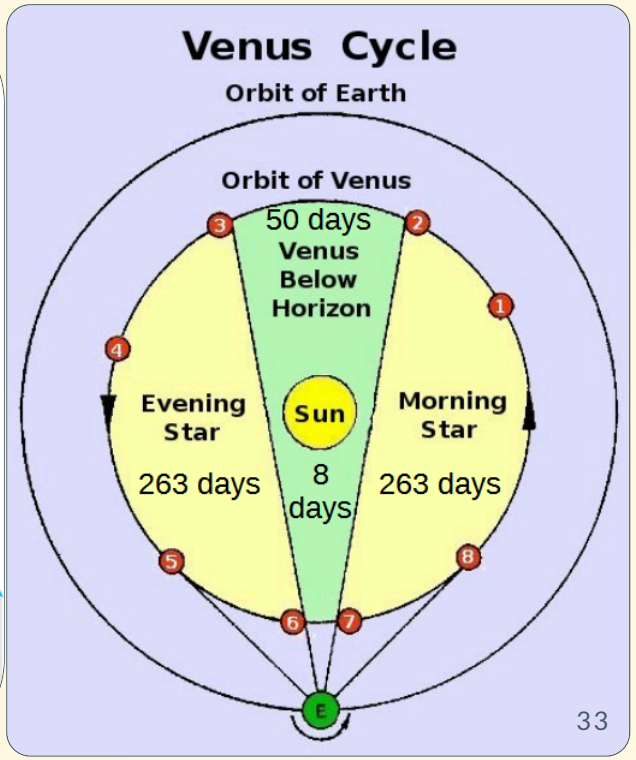
मध्यम ग्रह एक काल्पनिक ग्रह है जो कक्षा वृत्त पर घड़ी की सूई की विपरीत दिशा में समान गति से चलता है। मध्य ग्रह के केन्द्र से एक छोटा वृत्त मन्द-परिधि है जिस पर स्पष्ट ग्रह विपरीत दिशा में उसी गति से चलता है। केवल मध्य गति के कारण ग्रह क दिशा में रहता, पर मन्द परिधि पर की गति के कारण वह ख विन्दु पर दीखता है। स्पष्ट ग्रह का स्थान ख मन्दोच्च की दिशा में खिसक गया है, अतः कहा जा ता है कि मन्दोच्च द्वारा ग्रह आकर्षित होते हैं।

The path of Venus

Venus is the only planet that can be seen in the day time.
It is the brightest object in the sky after the sun and moon
It can be seen in the morning and evening and *never overhead* unless there is total solar eclipse
Bright enough to cast shadow in ideal conditions
It has phases like the moon when seen through telescope
It has a 8 year cycle of 5 periods of 584 days each (263+50+263+8)

Images from scarednumbers and bobmoler

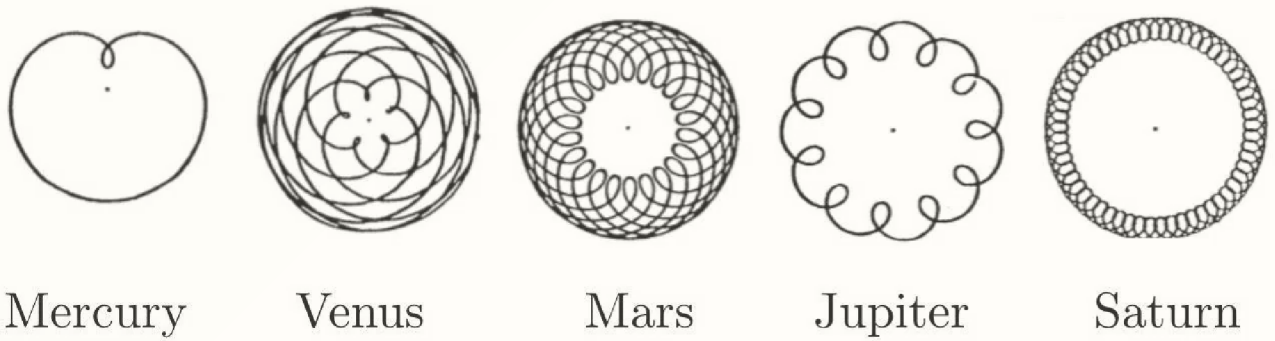




The path of Grahas

Mercury and Venus are inner grahas
The others are outer
Mercury and Venus are never seen overhead
The picture show 1 year of Mercury and 8 Venus path
Mars for 22? years, Jupiter for 12 and Saturn 30

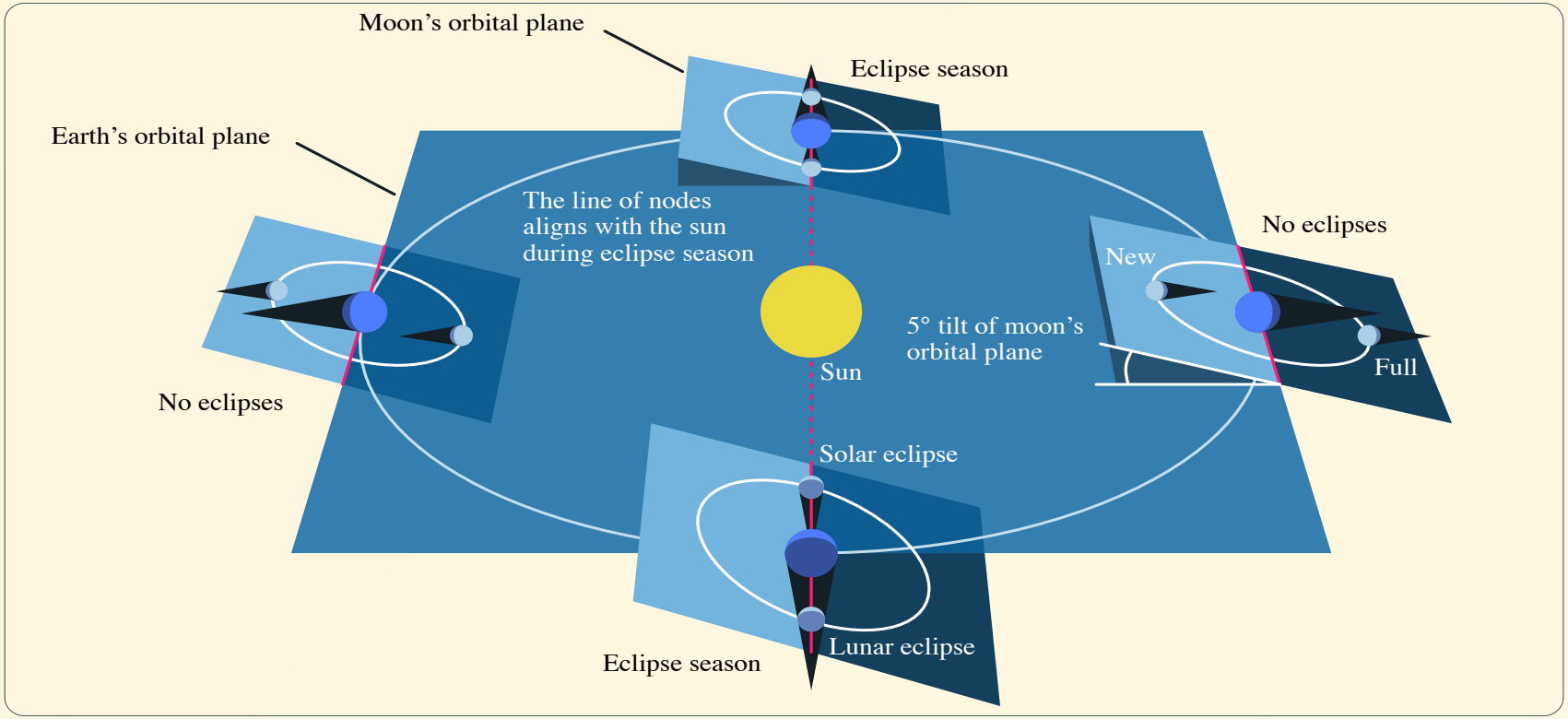
Image from reddit



Why is every full/new moon not an eclipse?

The moon's orbit is tilted by about 5° to the earth-sun plane ecliptic
The *nodes* are the *points* where the moon's orbit lies on the ecliptic
The ascending node is called *Rāhu* and the descending node is called *Ketu*
Solar eclipses occur new moon is near Rāhu or Ketu
Lunar eclipses occur when the full moon is near Rāhu or Ketu
Every 18 years, the moon's nodes return to the same nakṣatra - *3339* krishna pakṣa tithis RV 10.52.6 *त्रीणि शता त्री सहस्रांण्यग्निं त्रिंशच्च* देवा नवं चासपर्यन् ।

The picture below is from wikipedia



Recall questions - Lecture 3

#	Question	Answer
1	What is a graha?	A graha is a celestial body that grasps or seizes other celestials
2	What are the 5 tārāgrahas?	मङ्गलः बुधः गुरुः शुक्रः शनिः
3	What are the 2 mahāgrahas?	सूर्यः चन्द्रः
4	What are the 2 upagrahas/chāyāgrahas?	राहुः केतुः
5	What is the difference between a tārāgraha and a mahāgraha?	Tārāgrahas are the 5 that grasp the stars. Mahāgrahas are the sun and moon that are the dominant ones.
6	What are other names of मङ्गलः , बुधः	मङ्गलः(अङ्गारकः, कुजः, भौमः, लोहिताङ्गः, महीसुतः) बुधः(रौहिणेयः, सौम्यः)
7	What is शनिः named so?	The name शनिः is derived from the word शनैः चरति - moves slowly
8	Which gruhas can never be seen overhead apart from राहुः and केतुः	बुधः and शुक्रः . Because they are inner grahas
9	What is the difference between a solar and lunar eclipse?	Solar eclipse is when the moon is between the sun and the earth. Lunar eclipse is when the earth is between the sun and the moon.
10	What is a necessary condition for an eclipse to occur?	A straight line must connect sun, earth and moon.
11	How many types of eclipses does पराशरतंत्रम mention?	10 types of Lunar eclipses. grasping, mounting, smelling (upaghrāta), pressing (unmardana), cover (nirodha), licking (parileha), clockwise, anti-clockwise, ring, and total darknes