

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 <i>sun</i> dominates during daytime, creating <i>dawn, dusk, seasons</i>
		the <i>moon</i> waxes and wanes in cycles night over night creating <i>phases</i>
		the <i>stars</i> emerge in the night forming <i>recognizable patterns</i>
अन्तरिक्षः	Space-in-between	the <i>clouds</i> exists bringing <i>rains</i>
		the <i>meteors</i> shower through occasionally bringing <i>disasters</i>

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

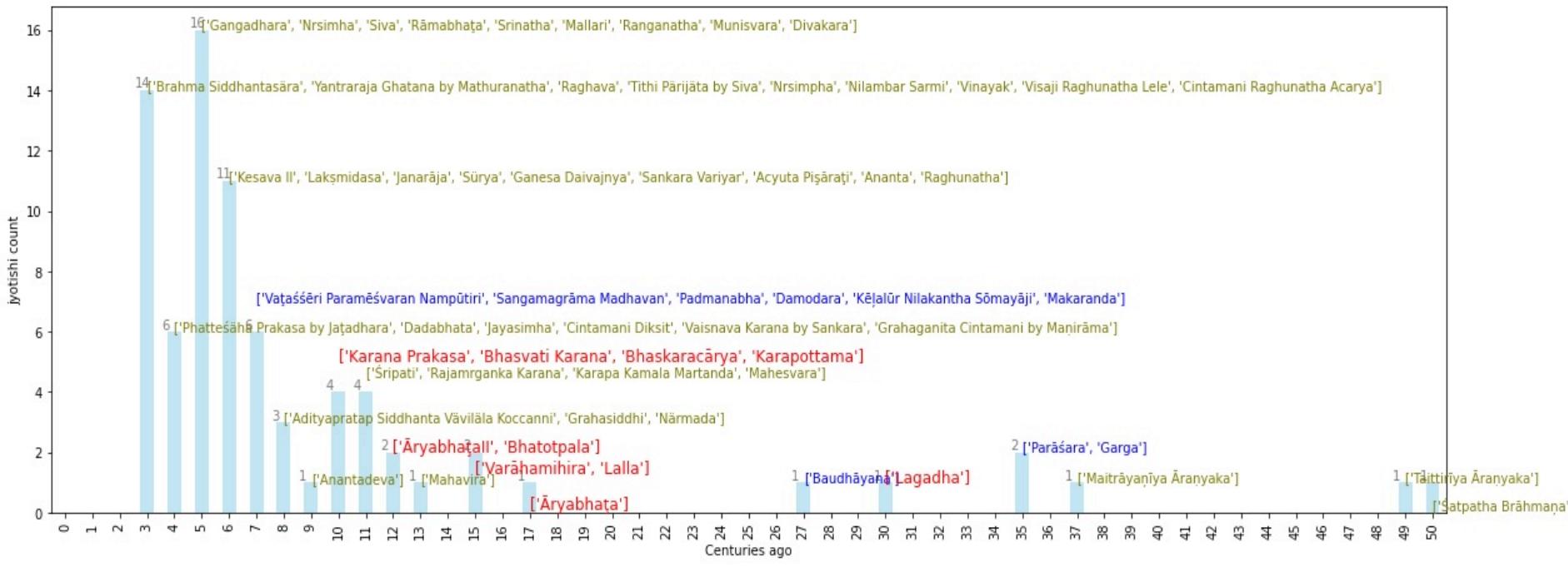
Purpose of these Observations

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, ḥtus, nakṣatras, drift of ḥtus

Few Sun names - various qualities

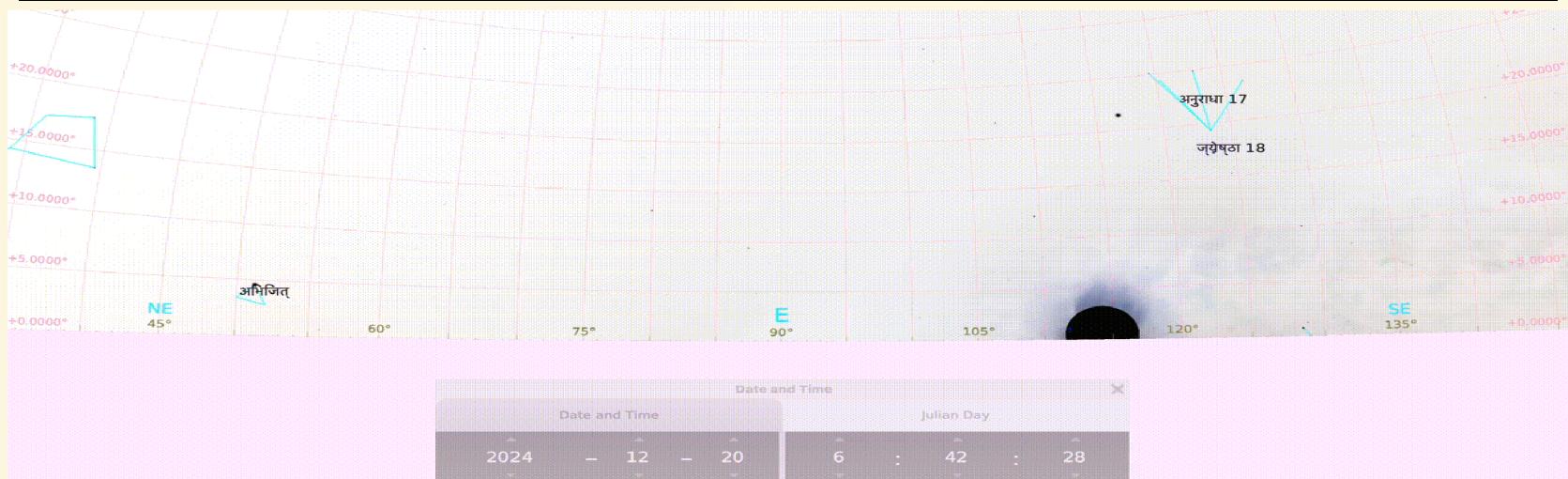
(some qualities observed, others inferred)

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

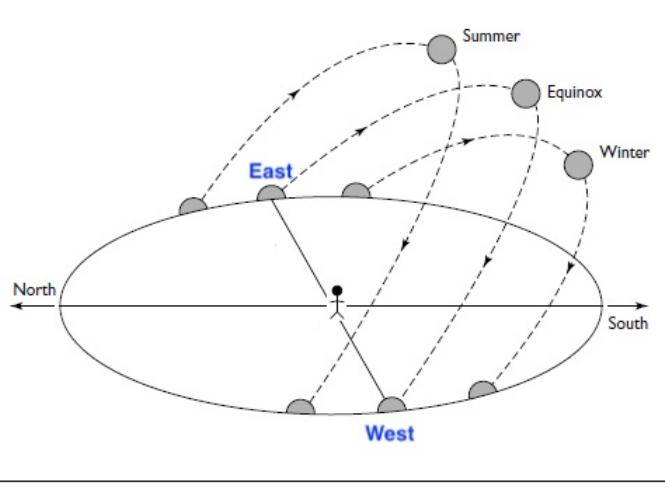
Observing the Sun's rhythms

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 its phases 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 nakṣatra 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	Bharanī 3	Kṛttikā 6	Rohiṇī 5	Mṛgaśiras 3	Ārdrā 1	Punarvasu 2	Puṣya 1	Aśleṣā 6
Maghā 6	Pūrvā Phalgunī 2	Uttara Phalgunī 2	Hasta 5	Citrā 1	Svātī 1	Viśākhā 2	Anurādhā 4	Jyeṣṭhā 3
Mūla 4	Pūrvā Aṣāḍhā 4	Uttara Aṣāḍhā 4	Śravaṇa 3	Śraviṣṭhā 4	Śatabhiṣā 1	Pūrvā 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 ḗtus - seasonal naṣatras . Such seasonal naṣatras also contain vital information on the epoch of the text.

The Sun, R̥tus and Nakṣatras

- Video of ~1½ minutes shows
- **Per year sun covers**
 - 2 ayanas
 - 6 ḗtu-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 horizon

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

Start of <i>uttaryāṇa/dakṣināyana</i>	solstice winter/summer
Mid of <i>uttaryāṇa/dakṣināyana</i>	<i>equinox spring/autumn</i>

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*

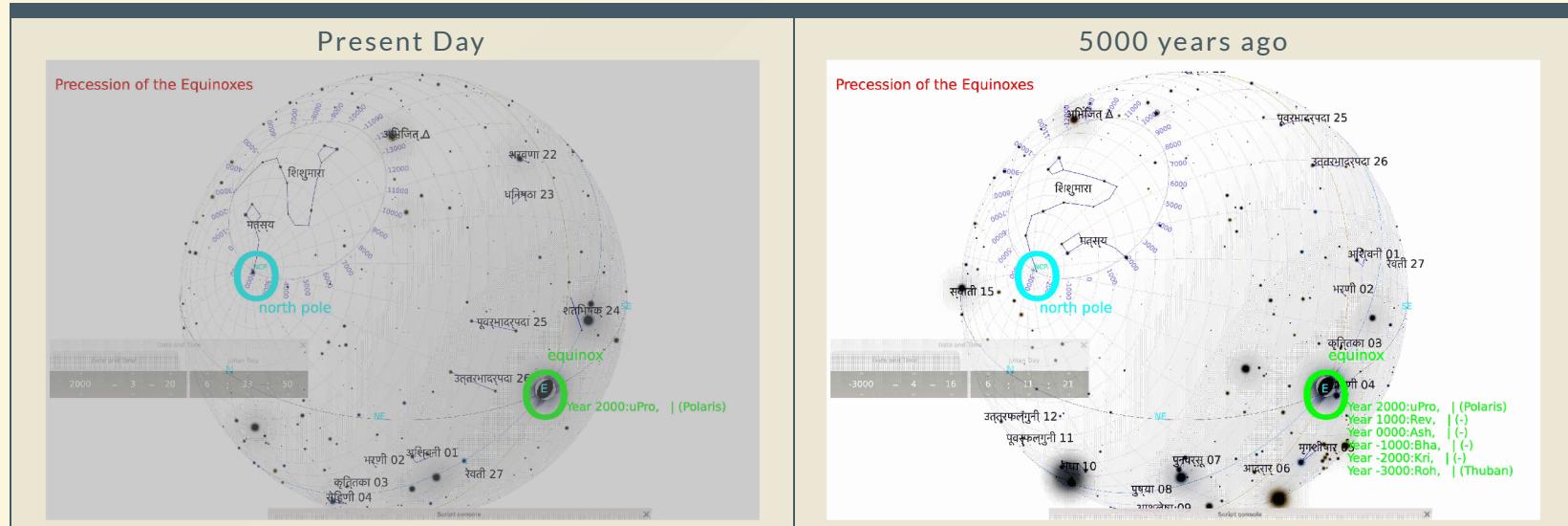
Every 1000 years

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

Effect of precession over millennia

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

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



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 ḥtu?
4	What is the most pleasant ḥtu? 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 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

Recap

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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
●	Amavāsyā 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	amāvāsyā+1	pūrnima	15 Śukla tithis	Moon moving away from sun
Kṛṣṇa Pakṣa	pūrnima+1	amāvāsyā	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 मातहम् तीर्गेषु month - all units of time from the word for moon

चन्द्रमासः	mean 29.5 days	From one pūrnima/amavāsyā to the next	<p>चैत्रः वैशाखः ज्येष्ठः आषाढः श्रावणः भाद्रपदः आश्विनः कार्तिकः मार्गशीर्षः पौषः माघः फाल्गुनः</p> <p>ज्येष्ठे वैशाखे ज्येष्ठे आषाढे श्रावणे भाद्रपदे आश्विने कार्तिके मार्गशीर्षे पौषे माघे फाल्गुने</p> <p><i>Full Moon approximately near the nakṣatra that names the month</i></p>
स्त्रमासः	mean 27.3 days	From one nakṣatra to the same	
सौरमासः	29 to 32 days	sun based	<p>मेषः वृषभः सिथुनः कटकः सिंहः कन्या: तुला वृश्चिकः धनुः मकरः कुम्भः मीनः</p> <p>चीत्तं तीर्त्ते वैवकाशी आ॒नि आ॒षि आ॒वणी पुराट्टाशी ज्यंप्पशी का॒र्त्तं तीर्त्ते का॒र्त्तं तीर्त्ते मा॒र्गकृष्णी तैत्त मा॒शी पञ्चकृष्णी</p> <p>मेऽग्ने इ॒दव॒ं मी॒मु॒न॒ं कर्त्त॒की॒िक॒क॒ं ची॒ङ्ग॒ं क॒न॒ी त॒ुला॒ं व॒ृश्चिक॒क॒ं य॒न॒ू म॒कर॒० क॒ु॒० मी॒०</p> <p>मधुः माधवः शुकः शुचिः नभः नाभः इषः उर्जः सहः सहस्यः तपः तपस्यः</p>

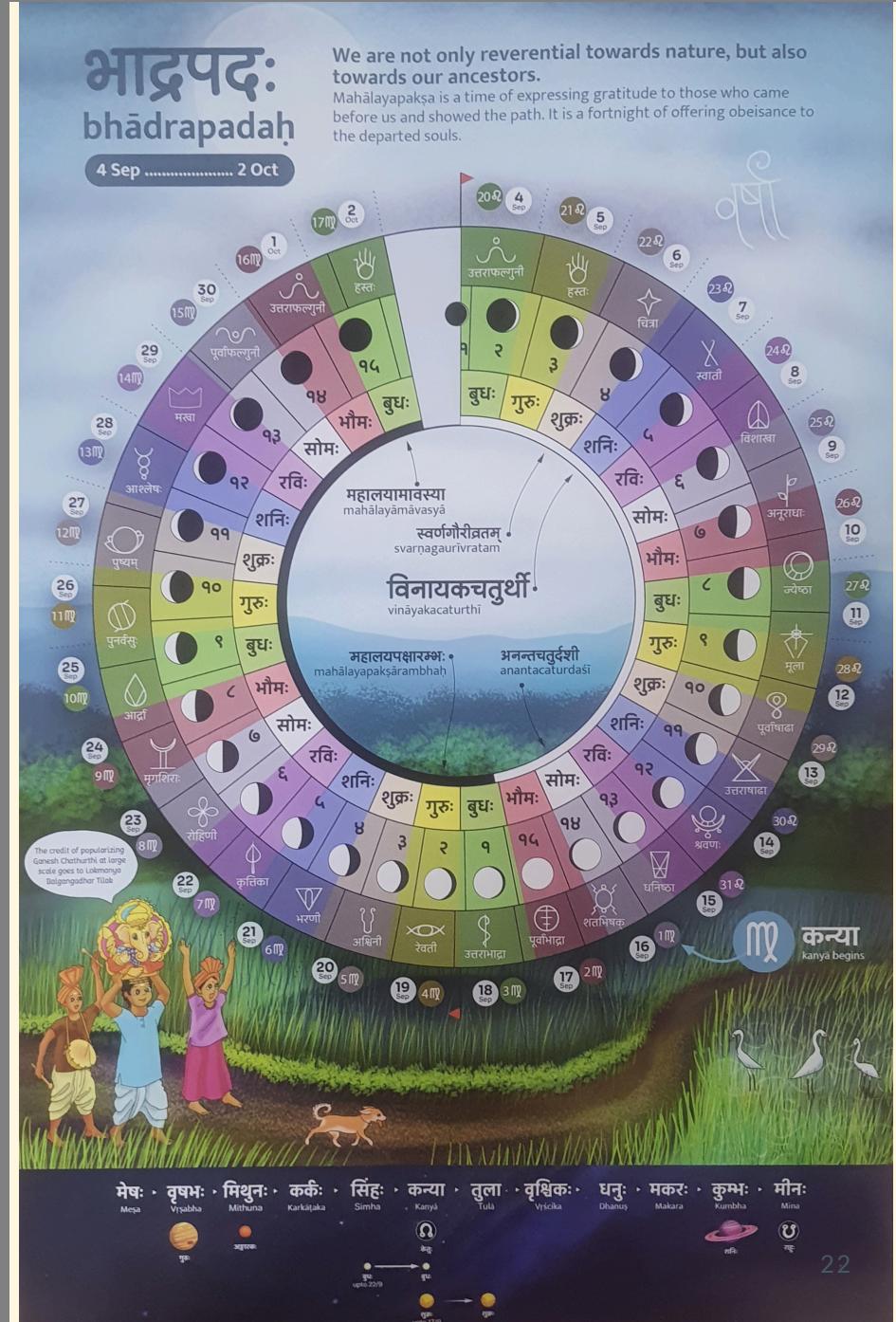
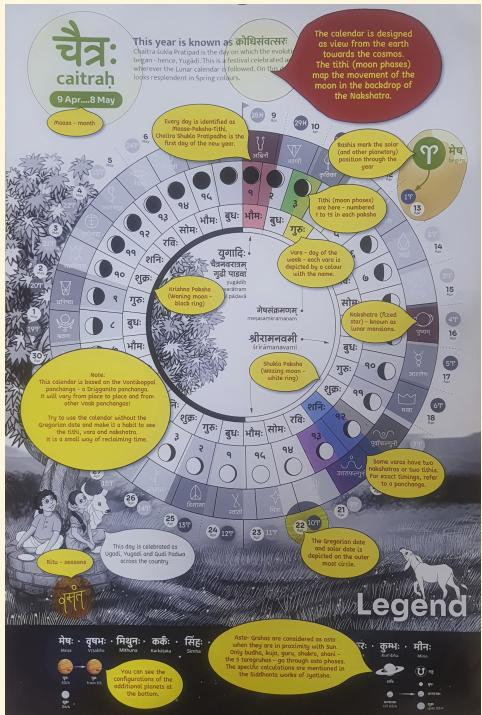
Panchāṅga - a Calendar System

- 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.

तिथि:	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 कृतिका रोहिणी मृगशीर्ष आर्द्रा पुनर्वसु पुष्य आश्लेषा मघा पूर्वफल्गुनी उत्तरफल्गुनी हस्त चित्रा स्वाति विशाखा अनुराधा ज्येष्ठा मूल पूर्वाषाढा उत्तराषाढा श्रवण श्रिविष्ठा 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	विष्कृम्भः 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 चतुष्पाद नागः किंस्तुष्टः

A sample month

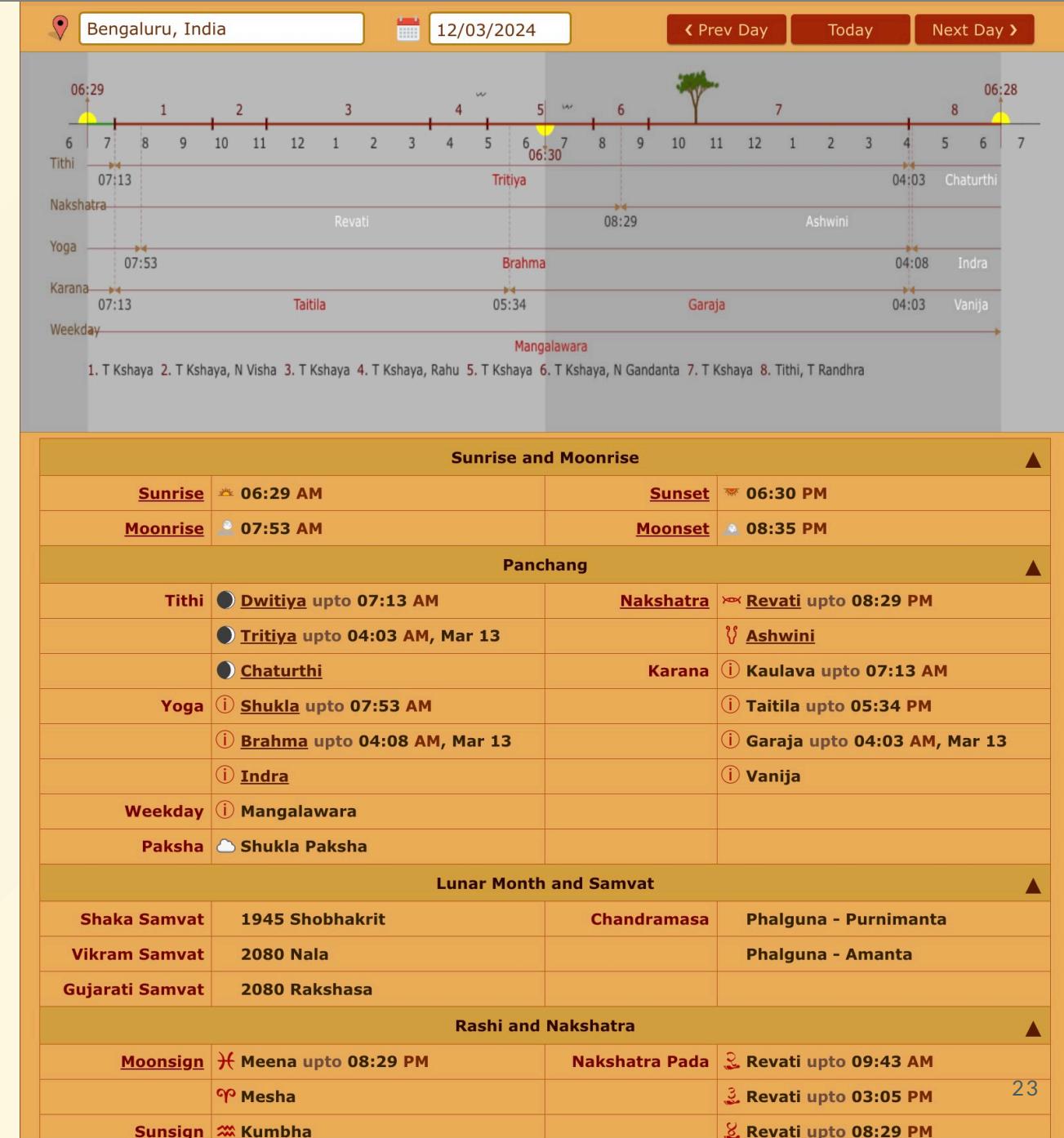
- Calendar by Dr Guha Vishwanathan MV
 - 1947 शालिवाहनसंवत्सरः, 2024 Gregorian , 2081 विक्रमसंवत्सरः:
 - Notice the **Tithi, Vāra, Nakṣatra, Gregorian day** for each day
 - Notice where each of these **start and end**
 - Notice the **Pakṣa** and the **Māsa** for each day
 - Find the **Sunrise and Sunset**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



A sample day

(drigpanchang.com)

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



Calendar Systems 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 naksatra 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 स्तूमासः in 1830 days to the nearest integer
11	What are rāka anumati kuhu and sinīvālī?
12	Around what time can the moon be seen overhead during Rama-navamī and Krishna-aṣṭamī.

End of Lecture 2