Indian Astronomy
through
Observations
from
Ancient Periods

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Outline of the talk

(~15 slides in ~60 minutes)

Topic	Info
	Lecture 1
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
	Lecture 2
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*

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

Few Sun names - various qualities

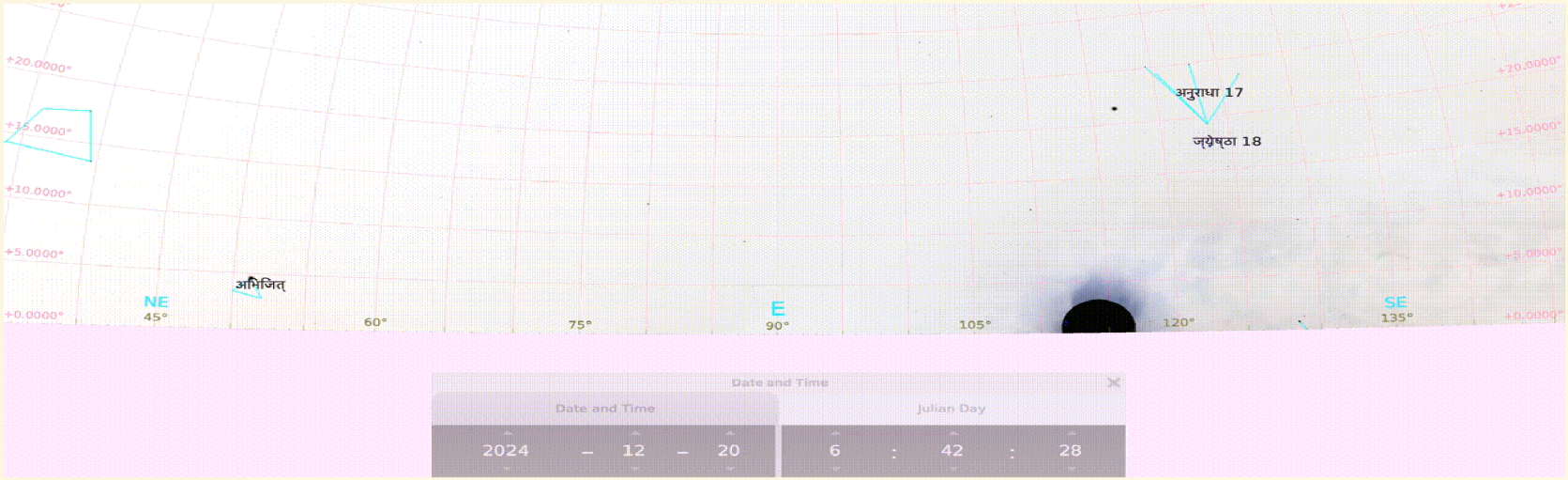
(some qualities observed, others inferred)

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	*सहस्रांशुः*	तपनः
सवितृ	*रविः*	पद्माक्षः	तेजसांराशिः	*छायानाथः*
तमिस्रहन्	कर्मसाक्षी	*जगच्चक्षुः*	लोकबन्धुः	त्रयीतनुः
प्रद्योतनः	दिनमणिः	खद्योतः	लोकबान्धवः	ज्योतिष्मान्

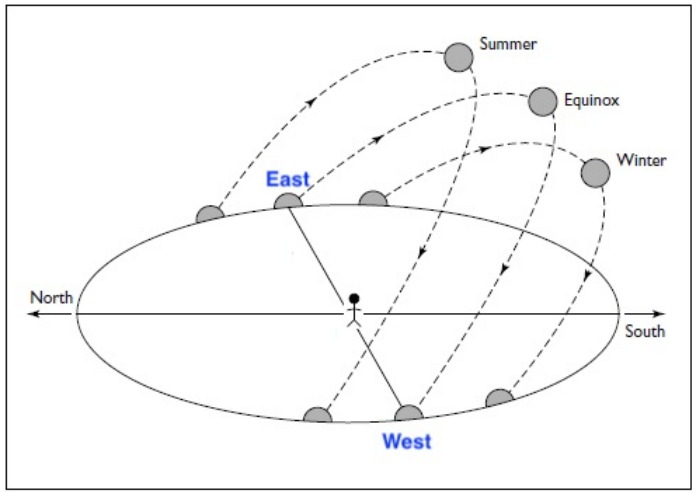
Observing the Sun's rhythmns

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

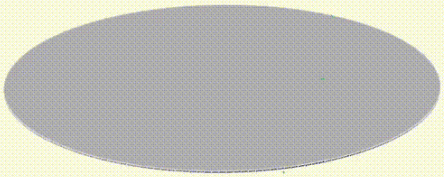
Season	Sunrise	Sunset
End-Summer	**north**-eastern horizon	**north**-western horizon
Mid-Spring/Autumn	**exact** east	**exact** west
Start-Winter	**south**-eastern horizon	**south**-western horizon



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

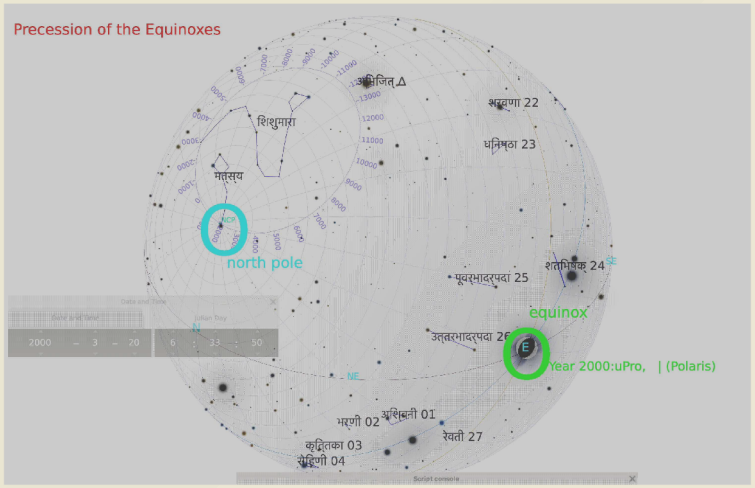
- The *spring equinox nakṣatra moves backward by one naḳsatra* due to precession
- i.e. **seasons move backward by one naḳsatra**

Effect of precession over millennia

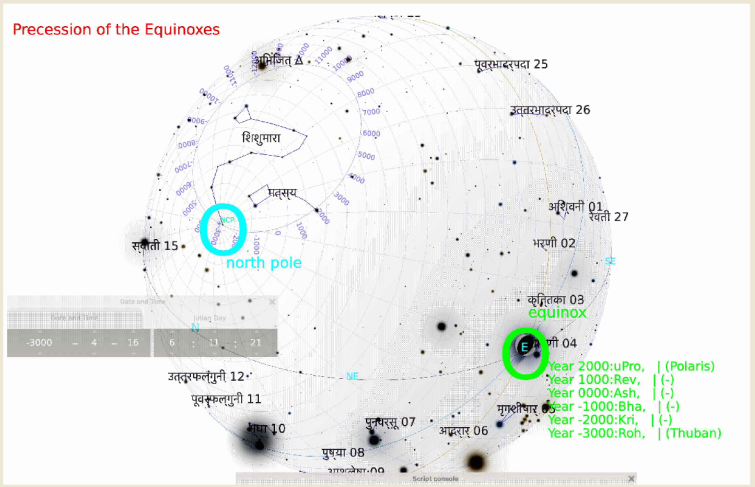
- About every *1000 years* the start of *seasons move backward by one naḳsatra*. **In addition the precession causes the pole star to change.**
- The following table/pictures shows the start of the spring equinox seasonal naḳsatra and the pole star for the last 5000 years.

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