Astro 301/ Fall 2005

(48310)

Introduction to Astronomy

Instructor: Professor Shardha Jogee

TAs: David Fisher, Donghui Jeong, and Miranda Nordhaus

Lecture 12 + 13: Tu Oct 11 Th Oct 13

http://www.as.utexas.edu/~sj/a301-fa05/

Lecture 12: Announcements

-- Quiz 2 back today

-- Cheating is severely punished: If you copy someone else hwk or let someone copy yours: you both get zero and a report to the Dean of students is filed.

Recent and Upcoming topics in class

-- Spin and Orbtital Motion of Earth
Day/ Night, Length of a year
-- Why do we have seasons?
Why do they occur in different months in N and S hemisphere?
-- Precession of the Earth's tilted axis.
-- Lunar phases

-- The Scientific Method

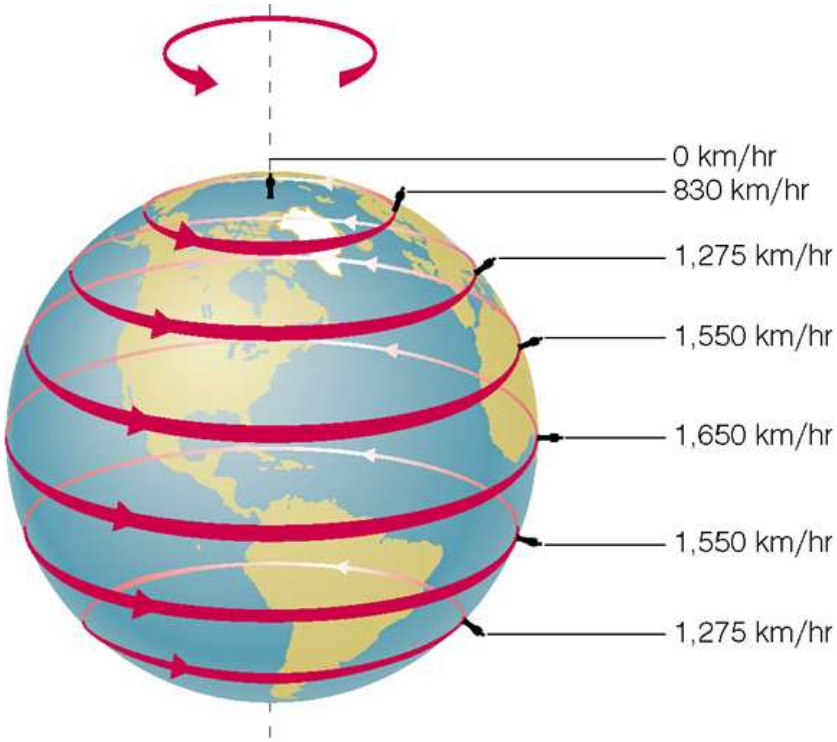
-- History and Science of Astronomy (300 BC to 1915 AD)
- Chinese, Egyptian and Babylonian astronomy
- Geocentric models and Greek Astronomy :
Thales, Pythagoras, Democritus, Plato Eudoxus, Aristotle,
[Aristarchus], Apollonius, Hipparcus, Ptolemy
- Library of Alexandria. House of Baghdad. Fall of Byzantine Empire.
- European Renaissance and Development of Geocentric models (1473-1670)
Copernicus, Brahe, Kepler, Galilei,
- Modern Astronomy: Newton,Einstein, Hubble

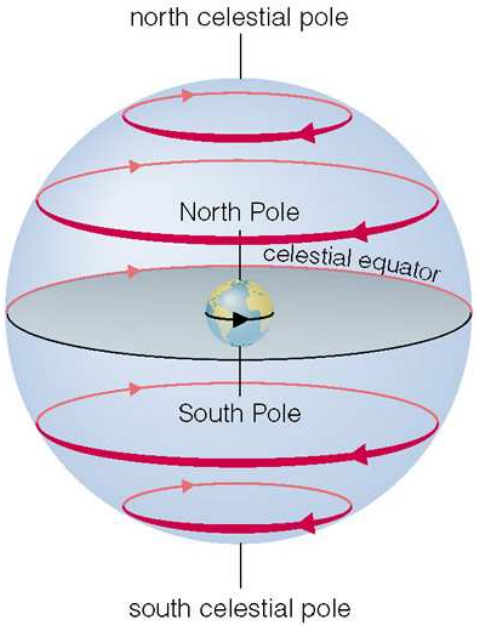
Spin and Orbtital Motion of Earth.

Tilted Axis of Earth

Day/Night, Seasons

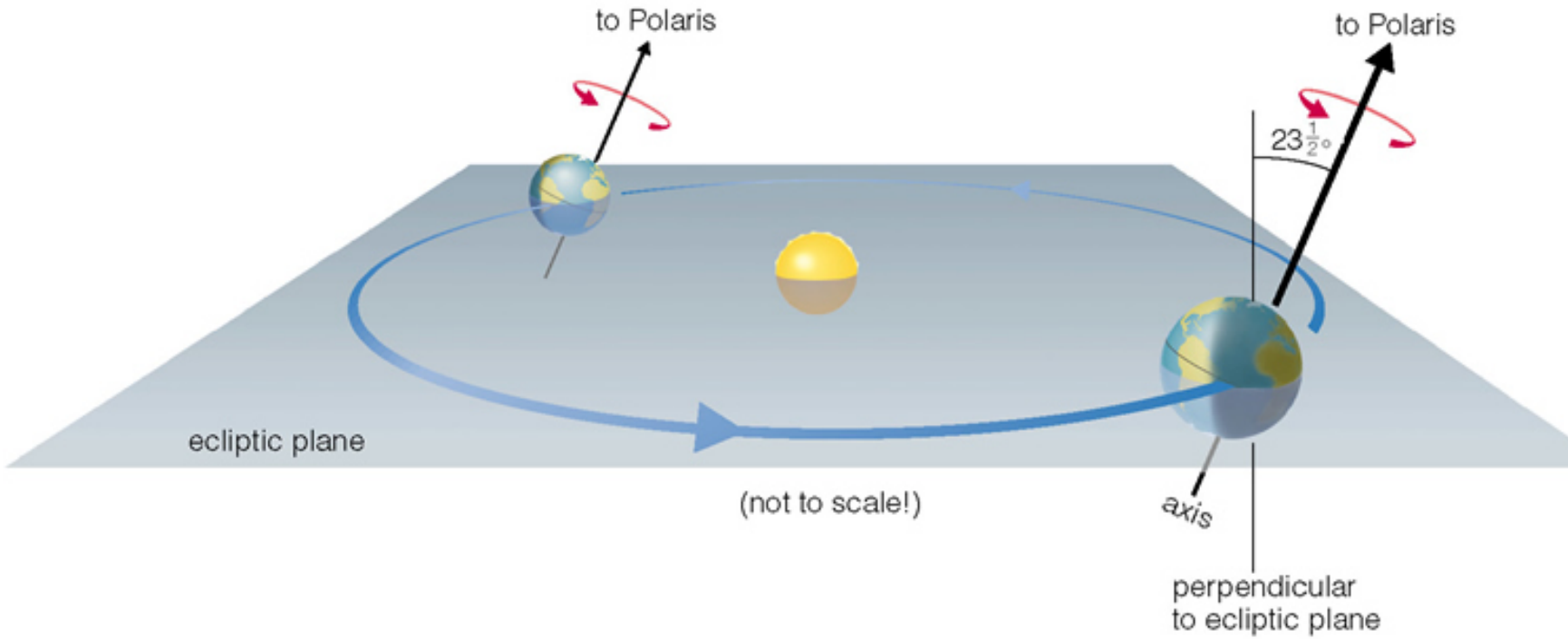
Spin of Earth about its axis

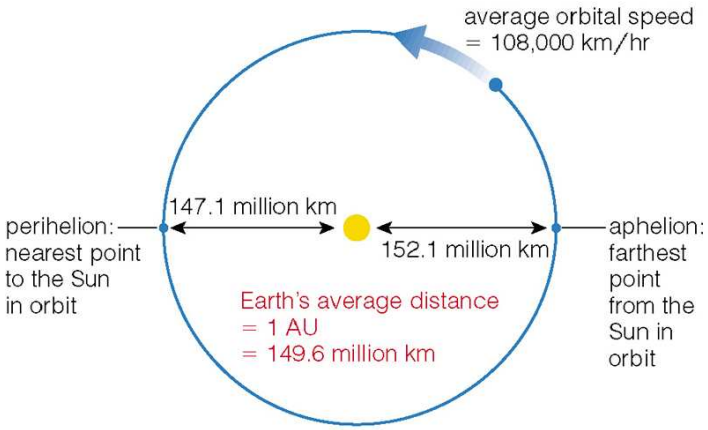




Why the Sun sets
to the West ?

Orbital Motion of Earth about Sun and Earth's tilted axis



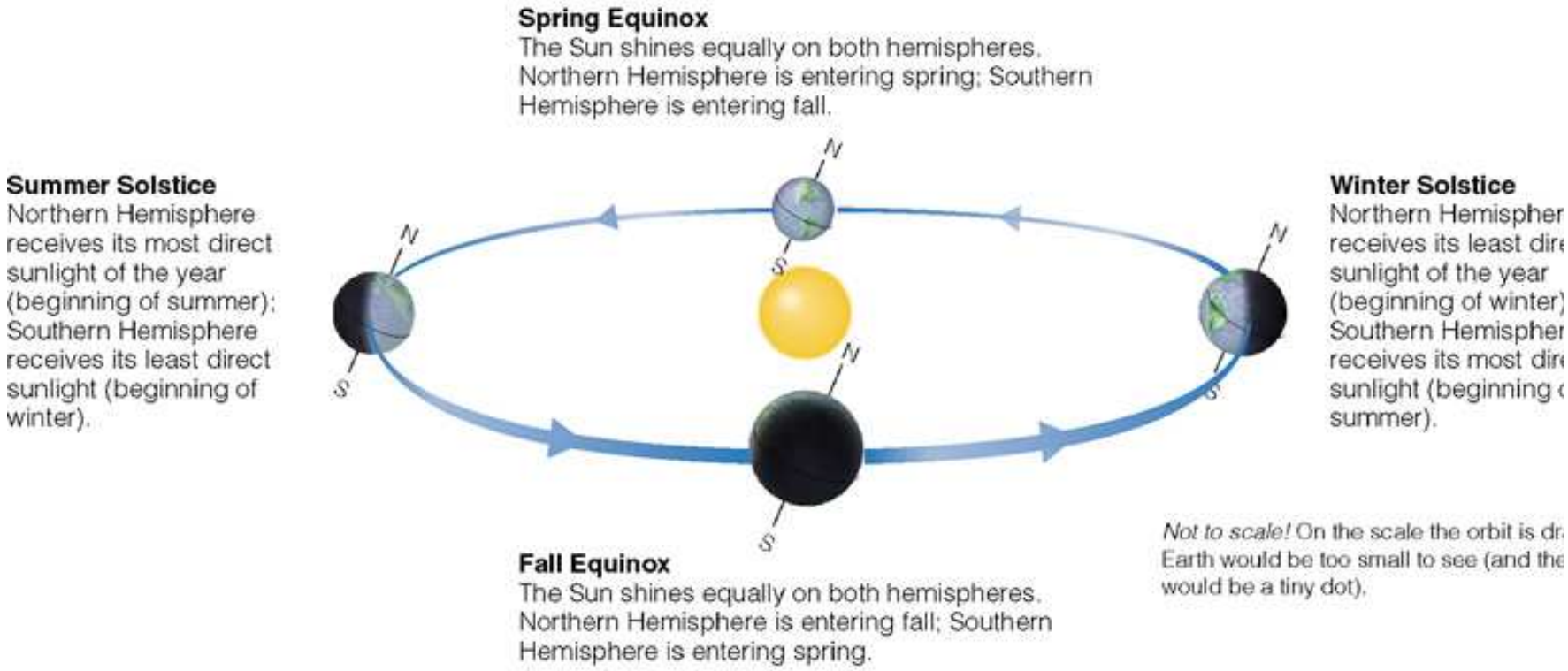


Tilt of Earth's axis with respect to (a line perpendicular to) the ecliptic plane = 23.5 deg

Why do we have seasons (winter, summer) ?

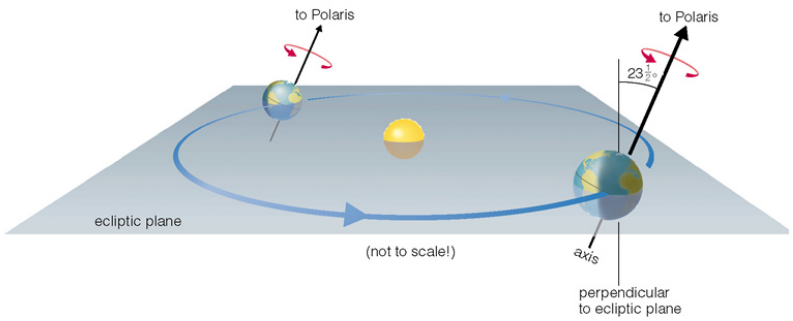
Why do opposite seasons occur in N and S hemisphere at a given time ?

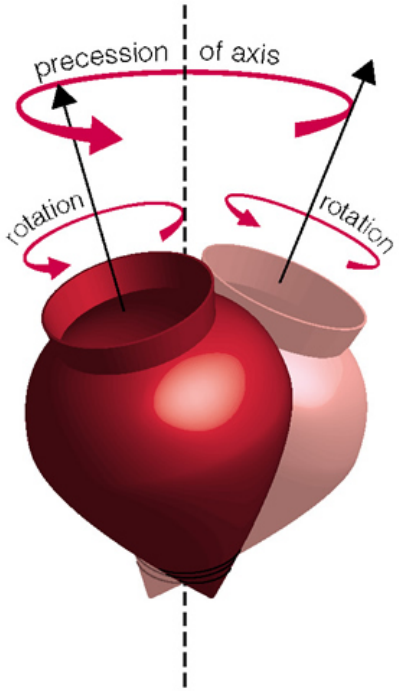
-- See in-class notes and movie (why_does_flux_sunlight_vary.swf)

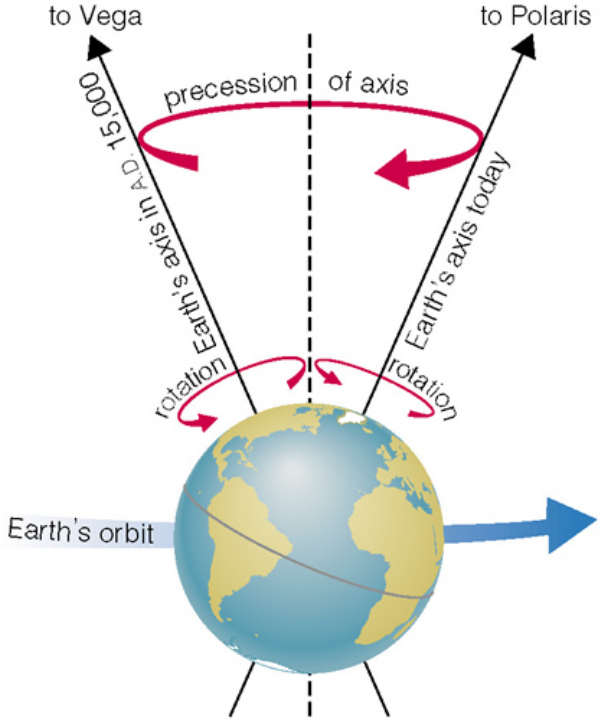


Precession of the Earth's tilted axis

Precession of the Earth's tilted axis





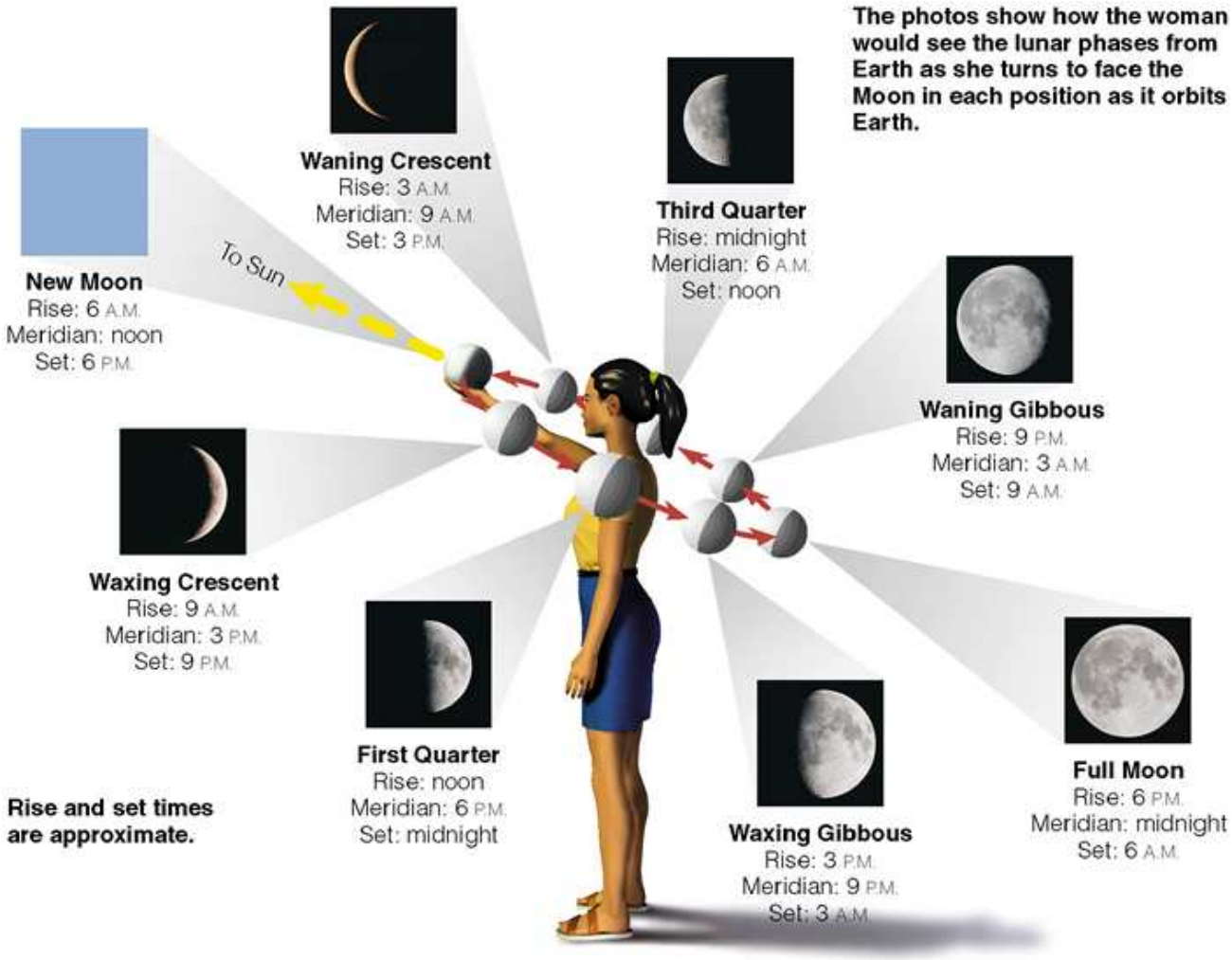


Tilt of the Earth's axis w.r.t. a line perpendicular to the ecliptic plane remains 23.5 deg, but the Earth's axis itself precesses (slowly rotates, a bit like a spinning top) about this line once every 26,000 years

Phases of the Moon

Lunar Cycle

- In class notes

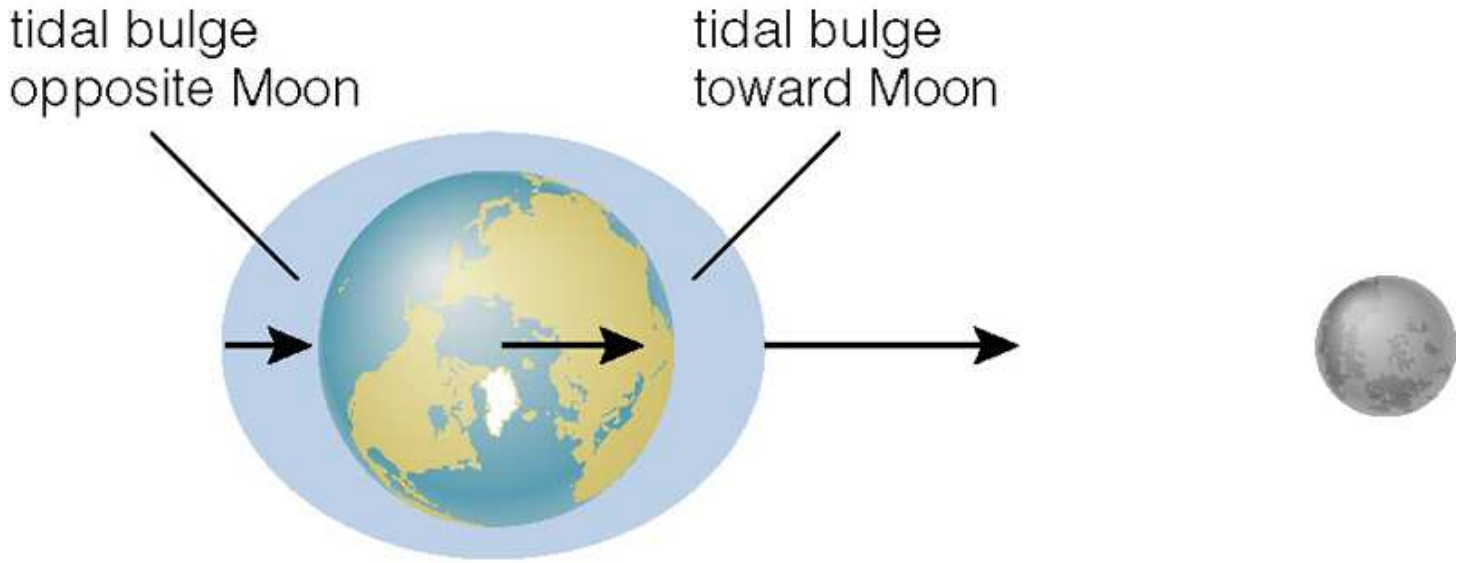


Lunar Cycle

- In class movie: phase_of_the moon.swf

Tides on Earth due to the Moon

Tides: Motion of Earth & Centripetal vs Gravitational forces

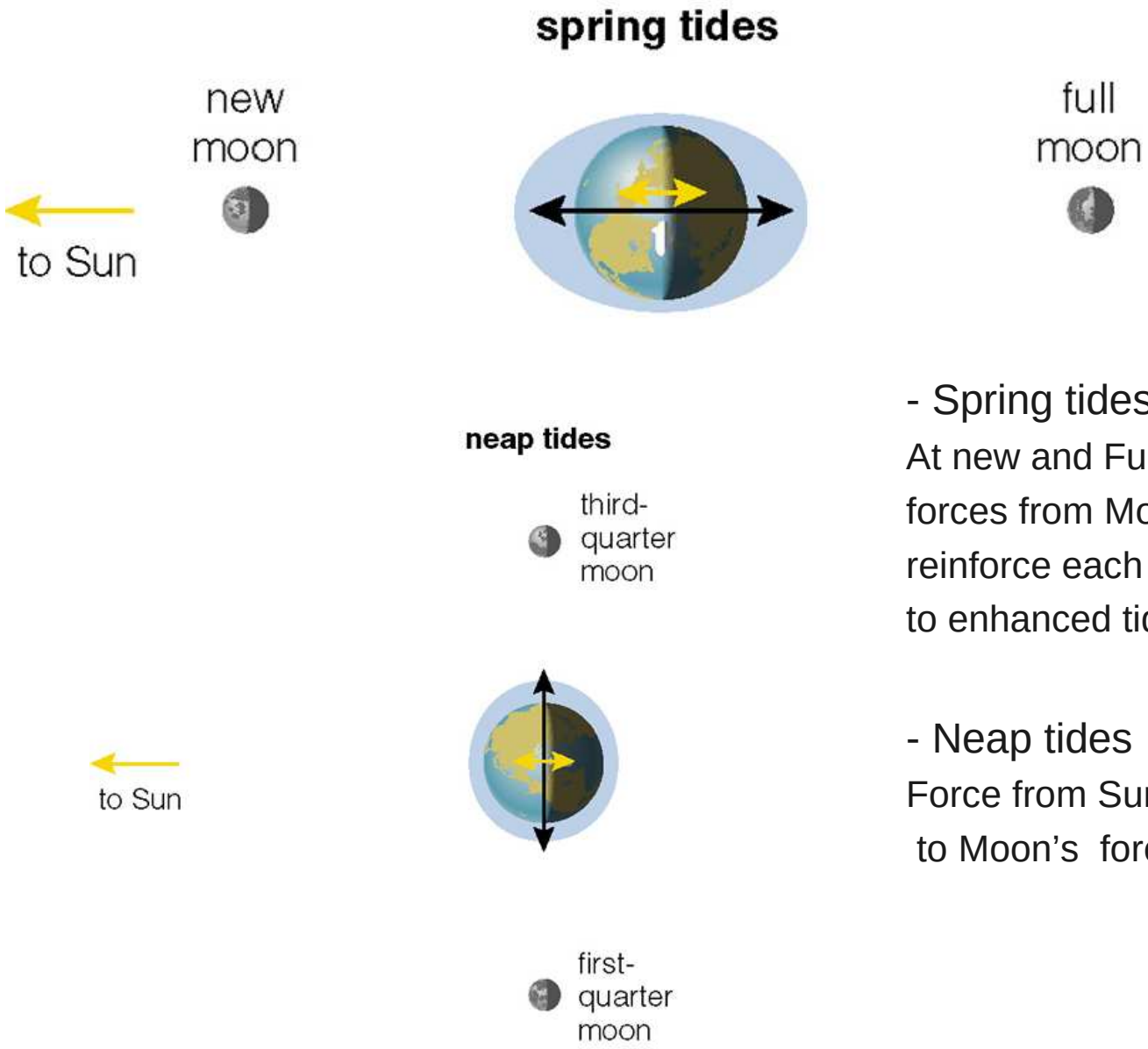


Not to scale! The real tidal bulge raises the oceans by only about 2 meters.

Why do we get tidal bulges of about same magnitude on both sides of Earth?

Why do we get 'high' tides twice a day?

Spring and Neap Tides



- Spring tides:

At new and Full moon, tidal forces from Moon and Sun reinforce each other leading to enhanced tides

- Neap tides

Force from Sun perpendicular to Moon's force on E\

Lecture 13: Announcements

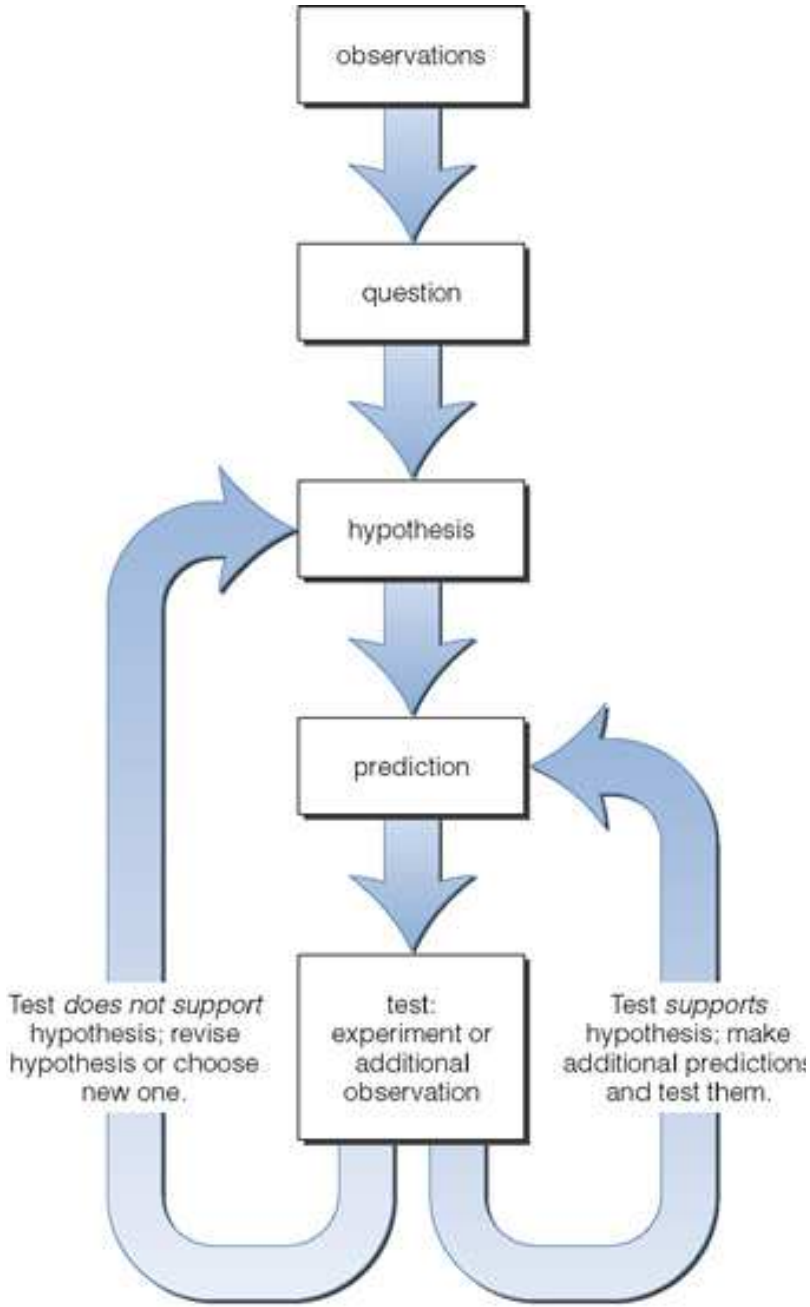
- Hwk2 back today. Solution set is posted outside

- Can the following students please see me after class?
  Anderson, Cahill, Ledbettter, Hickey, Rober T. Rogers

- Quiz 3 on Tue Oct 18 based on lecture 12, 13, and Chapter 3.
  PLEASE BRING A PENCIL (No 2 and ½ or softer) FOR THE QUIZ.

The Scientific Method

Scientific Method



Scientific Method

1. Different independent groups compile accurate observations

2. A scientific theory or model is proposed that

à explain all or a very large fraction of existing observations.

à makes predictions that can be tested by future observations.

3. Observations are made to check the predictions and to see if any counter examples directly contradicting the predictions can be found.

4. Science is non-dogmatic: If the scientific theory cannot explain all observations, this means that some aspect of it need to be refined or that an alternative model must be considered.

à This alternative model is a scientific model or theory if and only if it satisifes (2) above.

à An ad hoc guess that does not satisfy (2) is not a scientific model

Examples

- Newton's law of gravity vs Einstein's' theory of General relativity: both could explain a wide range of observations and both made testable predictions. They are both scientific theories. But Einstein's theory is better as only this theory can correctly predict the peculiar orbit of Mercury about the Sun or the existence of gravitational lensing.

- Theory of evolution satisfies (2). Many claim that intelligent design does not, and therefore, it is not a scientific model,and should not the taught in a science class. (Discuss)

Scientific Method: Discussion

1) Is science objective?

Funding….Media …Publish or perish

Integrity of peer review

Oppose the current experts

Sir E*ddington's most famous battle was the one with Subrahmanyan Chandrasekhar over the constitution of white dwarf stars. Eddington severely criticized the work of Chandrasekhar although his own ideas were outdated and incorrect. Other physicists silently backed Chandrasekhar but did not publicly discredit the great Eddington.*

2) If two scientific models can both explain existing observations, and then which theory or model is better?

A theory/law is more powerful if it can explain a wide array of phenomena with the same set of simple concept and with as few 'free' parameters as possible

e.g., Newton's law of gravity has same gravitational constant G for all cases: force between planets and Sun, force between you and your neighbor, force between star and galaxy .

This makes the law more general and powerful than a law which would stipulate a different G or a different relationship between force and mass for each different example.

History and Science of Astronomy

READ CHAPTER 3

See in-class notes

1) Early use or compilation of ‘celestial events’ for practical purposes , spiritual themes, superstitions

- 3000 BC Chinese astronomy
- 2700-2100 Egyptians & Babylonians

Use of 'celestial' objects for practical purposes by Egyptians

Egyptian used position of Sun on to determining time of day and night:

1) Night time : use position of stars in sky if know the date e.g., rise and set time of Orion in Dec; Egyptian sunclocks
2) Daytime: use position of Sun on sky.
   e.g., Shadow of sticks and obelisks, sundials

Ancient Egyptian Obelisk (83 ft)

See in-class notes

First scientific models to account for motion of celestial objects using logic and geometry, were developed by the Greek scientists

à 625 BC-150 AD **Greek scientists and geocentric models**

Main actors: Thales, Pythagoras, Democritus, Plato Eudoxus, Aristotle, [Aristarchus], Apollonius, Hipparcus, Ptolemy

Models were geocentric models made of nested spheres, epicycles,

Geocentric models and Greek Astronomy

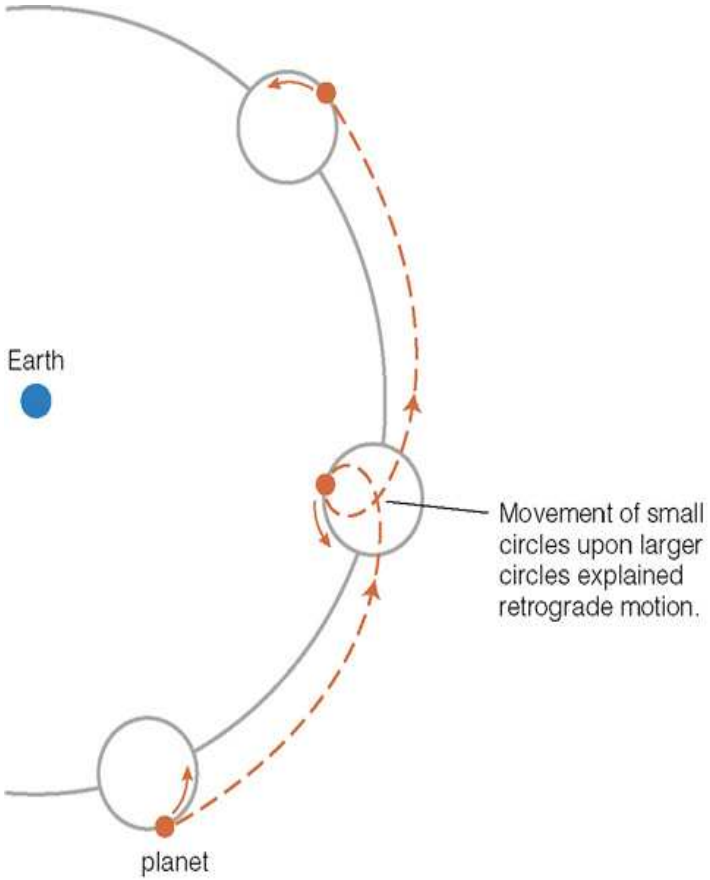
See in-class notes

Models used by Thales, Anaximander, Pythagoras, Democritus, Plato, Eudoxus, Aristotle

- Sphere and circles considered as the ‘perfect shapes’
- Geocentric models made of perfect shapes: spheres nested within spheres.
- Model used with various modifications by Plato, Eudoxus, and Aristotle

Geocentric models and Greek Astronomy

See in-class notes
Models based on epicycles used by Apollonius, Hipparcus, Ptolemy



- Epicycles= small circles whose centers move on larger circles called deferent

- Epicycles introduced by Apollonius and used in geocentric models by Hipparcus and Ptolemy

Geocentric models and Greek Astronomy

Points to Ponder

- How did the Greek scientists (625 BC -140 D) differ from earlier civilisations such as the Chinese, Egyptian and Babylonians ?
- Why did they fail to come up with heliocentric models even after 1000 years?
- To what extent was the scientific method used by the Greeks?

History and Science of Astronomy

- 3000 BC Chinese astronomy
- 2700-2100 Egyptians & Babylonians

- 625 BC-150 AD **Greek scientists and geocentric models** (Thales, Pythagoras, Democritus, Plato Eudoxus, Aristotle, [Aristarchus], Apollonius, Hipparcus, Ptolemy)

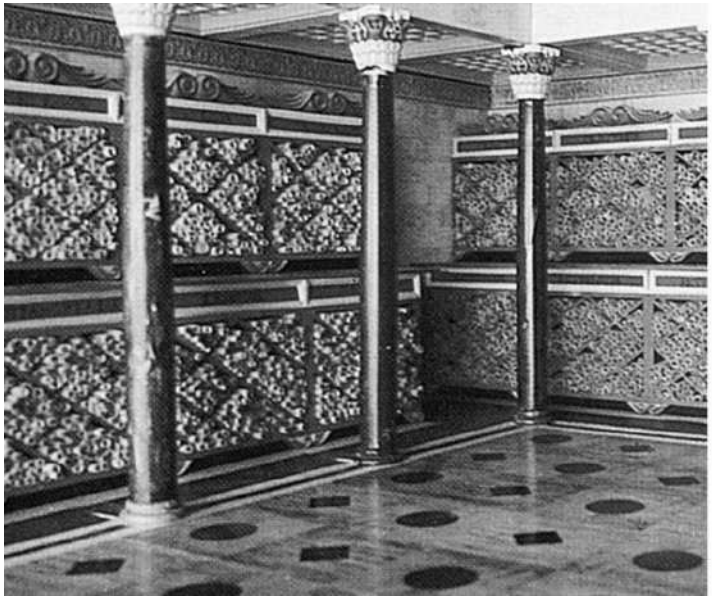
- 300 BC Expansion of Greek empire into Middle East (Egypt, Mesopotoamia)

- 300 BC-400 AD Library of Alexandria

Library of Alexandria (300 BC-400 AD)

- Founded in Alexandria by Alexander the Great. Lasted 700 years (300 BC –400 AD)
- Half a million scrolls on papyrus. Great learning center.
- Director (Hypatia) was killed by anti-intellectual movements in ~415 AD

(Artist reconstruction)
Great Hall and Scroll room
in Library of Alexandria



History and Science of Astronomy

- 3000 BC — Chinese astronomy
- 2700-2100 — Egyptians & Babylonians

- 625 BC-150 AD — **Greek scientists and geocentric models** (Thales, Pythagoras, Democritus, Plato Eudoxus, Aristotle, [Aristarchus], Apollonius, Hipparcus, Ptolemy)

- 300 BC — Expansion of Greek empire into Middle East (Egypt, Mesopotoamia)

- 300 BC-400 AD — Library of Alexandria

- 600-800 AD — House of Baghdad; compilation of knowledge by Arabs from Egyptians, Greeks, Hindu, Chinese. Development of arithmetic.

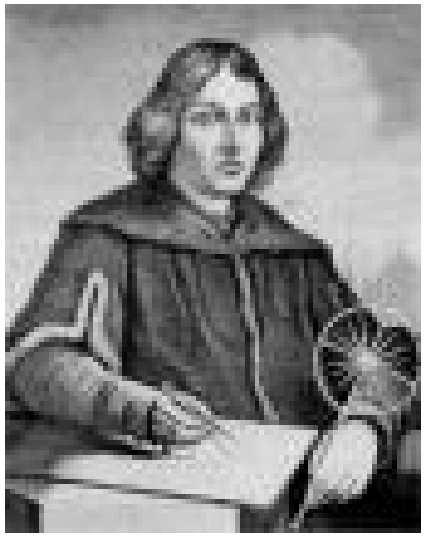
- 800-1400 — Knowledge compiled by Arabs spreads throughout the Byzantine Empire

- 1453 — Capital of Byzantine Empire, Constantinople, falls to the Turks. Eastern scholars move to Europe transferring knowledge, leading to European Renaissannce

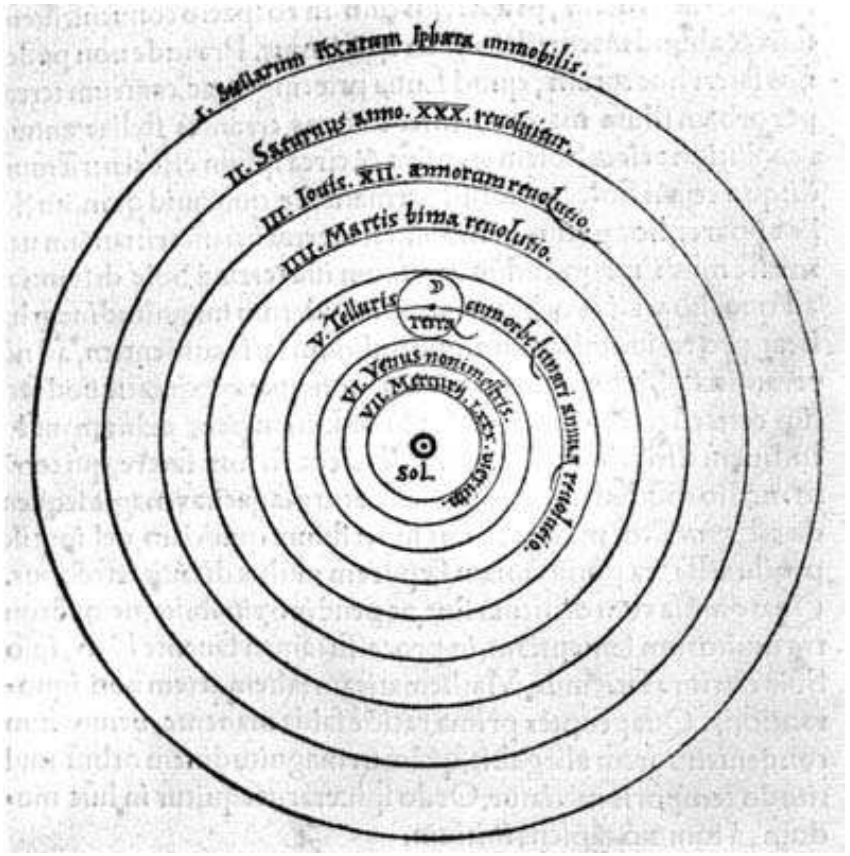
- 1473—1642 — **Heliocentric models and birth of modern astronomy** (Copernicus, Brahe, Kepler, Galilei)

Heliocentric Models and Modern Astronomy

Heliocentric Models and Modern Astronomy



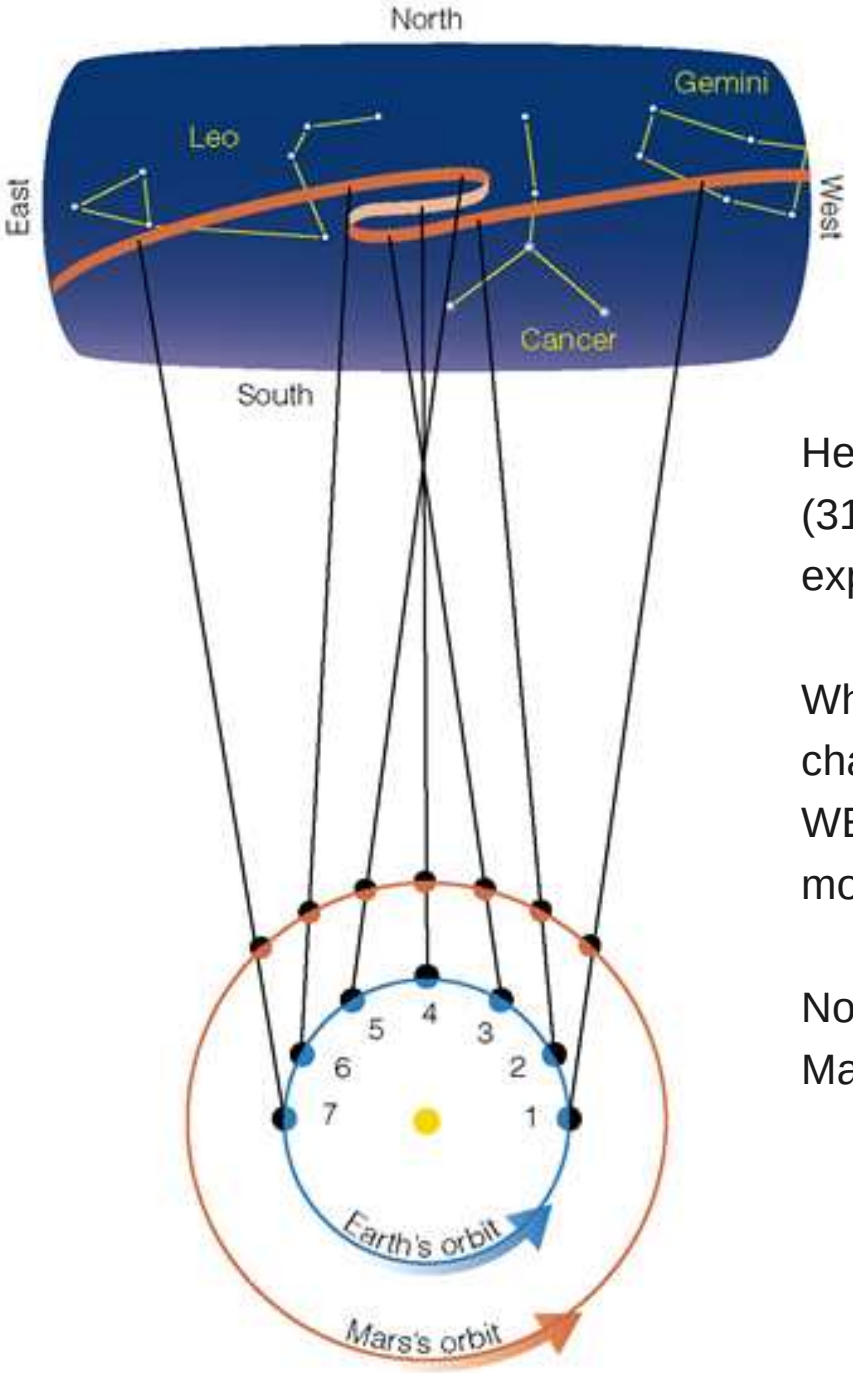
Copernicus (1473-1543)
Polish



De Revolutionibus Diagram

- Heliocentric model made of perfectly circular orbits to which a very large no of epicycles had to be added in order to account for observed planetary motions
- 'De Revolutionibus Orbium Celelstium' = "Concerning the Revolutions of the Heavenly Spheres" published in 1543 on the day he died.

Heliocentric Models and Modern Astronomy



Heliocentric models, like those of Aristarchus (310-230 BC) and Copernicus (1500s) easily explain apparent retrograde motion of Mars

When the line of sight from Earth to Mars changes from pointing Eastward (or North) to WESTWARD, then see apparent retrograde motion of Mars

Note: Earth's orbital period about Sun=1.0 year
Mars orbital period about Sun = 1.88 years.

Points to Ponder

Copernicus's heliocentric model

à did not predict the position of planets to a better accuracy than the geocentric model of Ptolemy.

à had so many epicycles that it was as complex as the geocentric model of Ptolemy.

Was Copernicus and his models 'overrated'? Or did he really deserve a lot of credit for his contribution to astronomy?