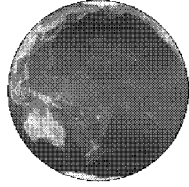
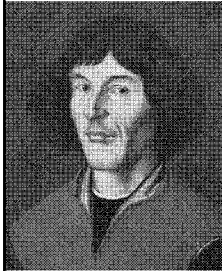


Renaissance Cosmology



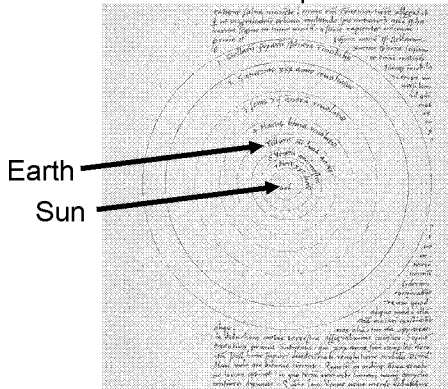
Wednesday, September 30

Next Planetarium Shows: Tonight 7 pm, Tomorrow 7 pm



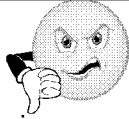
Reviver of "heliocentrism":
Nicolaus Copernicus
(Polish: 1473 – 1543)

Basic structure of Copernicus' model:



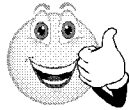
Geocentric model (Ptolemy):

- Earth in central location
- Celestial sphere rotating about axis
- Sun orbiting around Earth

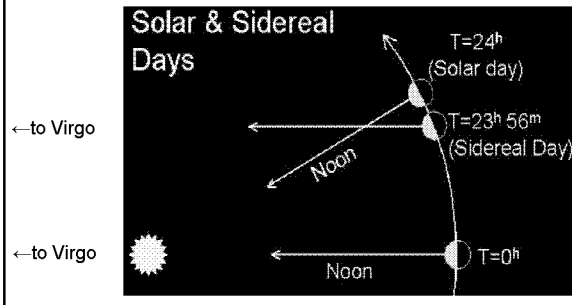


Heliocentric (Aristarchus, Copernicus):

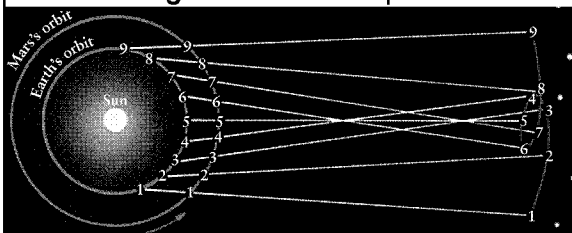
- Sun in central location
- Earth rotating about axis
- Earth orbiting around Sun



Heliocentric model explains difference between **sidereal** day (23 hr, 56 min) and **solar** day (24 hr).

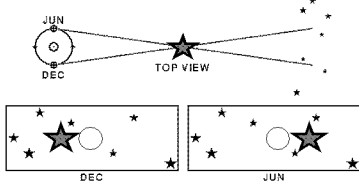


Heliocentric model explains **retrograde motion** of planets.



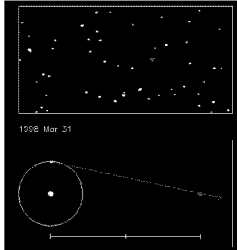
Planets farther from Sun orbit more slowly.
What does this imply when we look at **Mars** (larger orbit than our own)?

Heliocentric model:
distance from Sun to **stars** must be much greater than distance from Sun to **Earth**.



Since Earth orbits Sun, stars must show **parallax** (a shift in apparent position) over the course of half a year.

Observation: Parallax of stars is **too small** to be seen by the naked eye.



Implication: distance to stars is several **thousand** times Earth – Sun distance.

Cosmological Models:

Version 1.0:
"Superdome" model

Version 2.0:
Geocentric model

Version 3.0:
Heliocentric model

Radical aspects of Copernicus' model:
Earth is moving.
Earth is not central.
Space is big – REALLY big.

Conservative aspects:
Stars still glued to celestial sphere.
Epicyles are still required.

Startling Realization!

“Planets” (Mercury, Venus, Mars, Jupiter, Saturn) are opaque spheres orbiting the Sun – just like Earth!

Earth is a planet: no division between “perfect” heavens and “corrupt” Earth.

Another Startling Realization!

Stars look small & dim because they're far away; they're actually large, glowing spheres – just like the Sun!

Sun is a star: universe is full of glowing, spherical, Sun-like objects.

Early adopter of the Copernican model:
Thomas Digges (English: 1546-1595)



Cosmological model version 3.1:
Heliocentric, with **no celestial sphere**

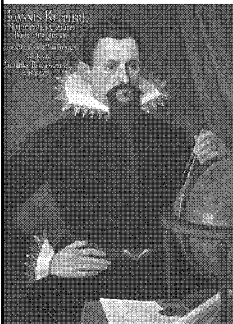
Very distant

More distant

Nearby

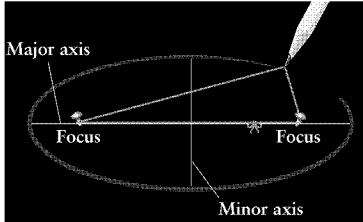
Infinite universe, filled with stars.
Nearby stars are brighter.
More distant stars are dimmer.
Very distant stars are too dim to be seen.

Johannes Kepler (German: 1571-1630)
discarded epicycles.



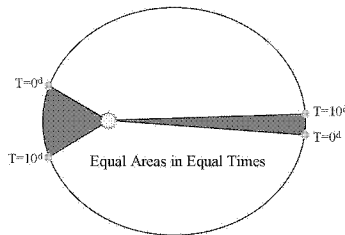
Kepler's 1st Law
of Planetary Motion:
Orbits of planets around
the Sun are **ellipses** with
the Sun at one **focus**.

Ellipse = oval built around two points, called **foci** (or **foci**).



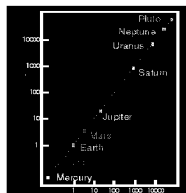
Take a line from one focus, to **any** point on ellipse, to other focus: length = **constant**.

Kepler's 2nd Law of Planetary Motion: Planets move **fastest** when **closest** to the Sun.

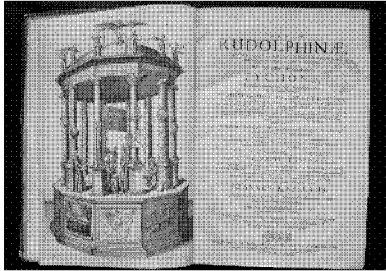


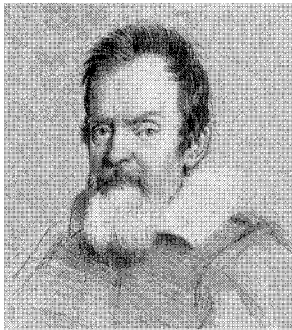
Kepler's 3rd Law of Planetary Motion:

The **square** of a planet's orbital period is proportional to the **cube** of its average distance from the Sun.



With laws of planetary motion, Kepler made **more accurate** predictions of planetary positions.



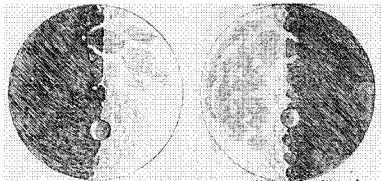


Galileo Galilei
(Italian: 1564-1642)

Among the first to observe with a telescope.

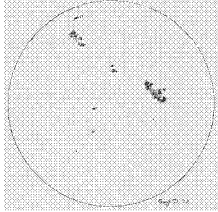
Observations of Galileo supporting heliocentric model:

1) The Moon has mountains.



Aristotle & Ptolemy: Moon is a perfect sphere.
Galileo: Moon is no more perfect than Earth.

2) The Sun has spots.
(warning: don't try this yourself)



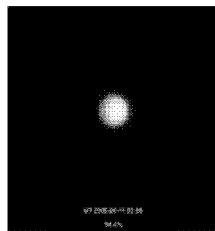
Sun is not perfect.
Motion of spots indicates Sun is **rotating**.
If Sun rotates, why not Earth?

3) Jupiter has moons.



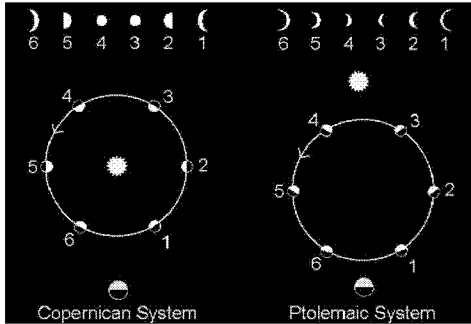
Four "Galilean" satellites of Jupiter.
The Earth cannot be the center of **all**
orbits in the universe.

4) Venus shows phases.



Big in angular size when nearly new,
small when nearly full.

Observations consistent with Copernicus,
inconsistent with Ptolemy.



"And new philosophy calls all in doubt,
The element of fire is quite put out,
The Sun is lost and the Earth, and no man's wit
Can well direct him where to look for it."
– John Donne, 1611

"The eternal silence of these infinite spaces terrifies me."
– Blaise Pascal, 1662

"When the heavens were a little blue arch, stuck with
stars, I thought the universe was too strait and close; I
was almost stifled for want of air. But now it is enlarged
in height and breadth...I begin to breathe with more
freedom, and think the universe to be incomparably
more magnificent than it was before."
– Bernard de Fontenelle, 1686

Friday's Lecture:
Tools of Modern Cosmology

Reminders:

Problem set #1 due Wednesday, Oct 7.
Have you read Chapters 1 & 2?
