Lecture 14: Announcements

-- Quiz 3 today

-- Hwk3 and the reading assignment for question 5 are on class website

-- The following students should please see me after class: Carla Rogers

Recent and Upcoming topics in class

---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.
- Development of Geocentric models during European Renaissance(1473-1670)
  Copernicus, Brahe, Kepler, Galilei <-- End of L13
  Kepler's laws of motion
- Modern Astronomy: Newton, Einstein, Hubble

--- Energy
-- Forms of Energy.
-- Principle of Conservation of Energy
-- Equivalence of Mass and Energy or $E=mc^2$
  Fission , fusion, accretion of matter onto a black hole
-- General Principles of Nuclear Fusion

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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.

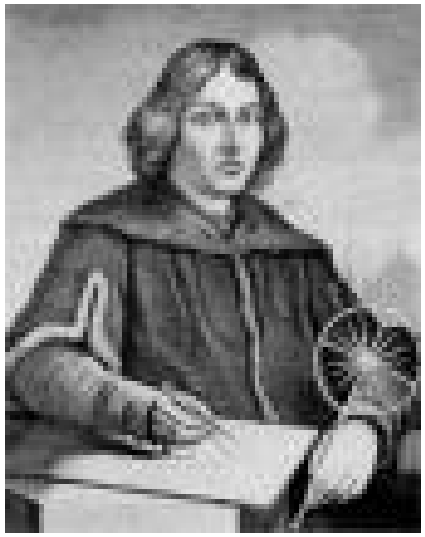
- 800-1400 — Knowledge compiled by Arabs spreads throughout the Byzantine Empire

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

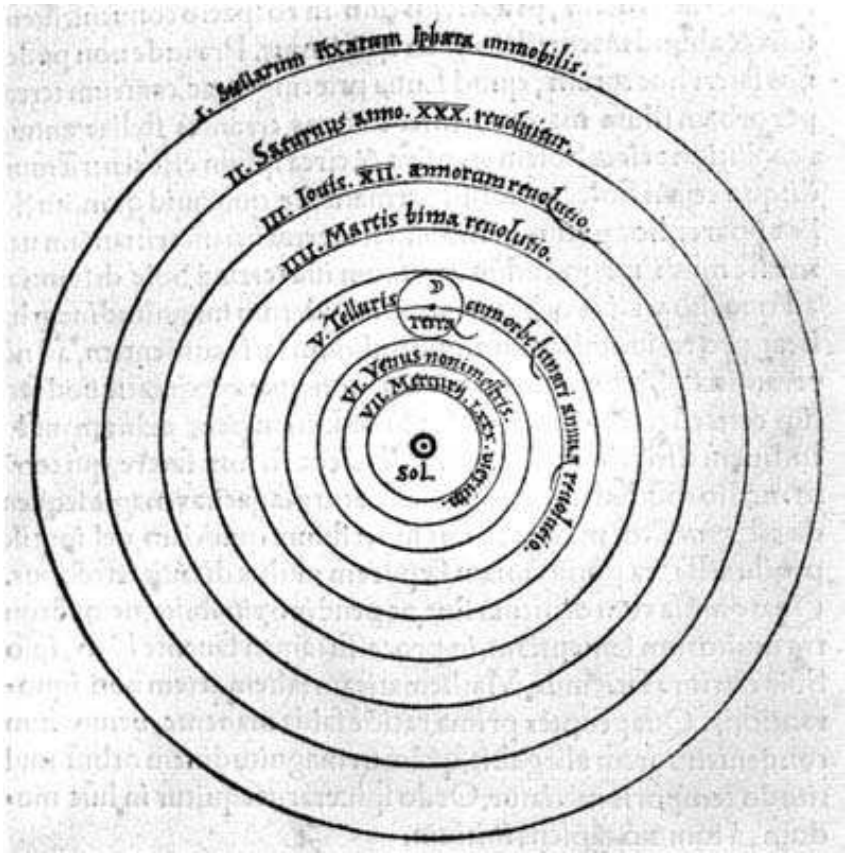
- 1473—1642 — **Heliocentric models and birth of modern astronomy** (Copernicus, Brahe, Kepler, Galilei)

Heliocentric Models and Modern Astronomy

Heliocentric Models and Modern Astronomy



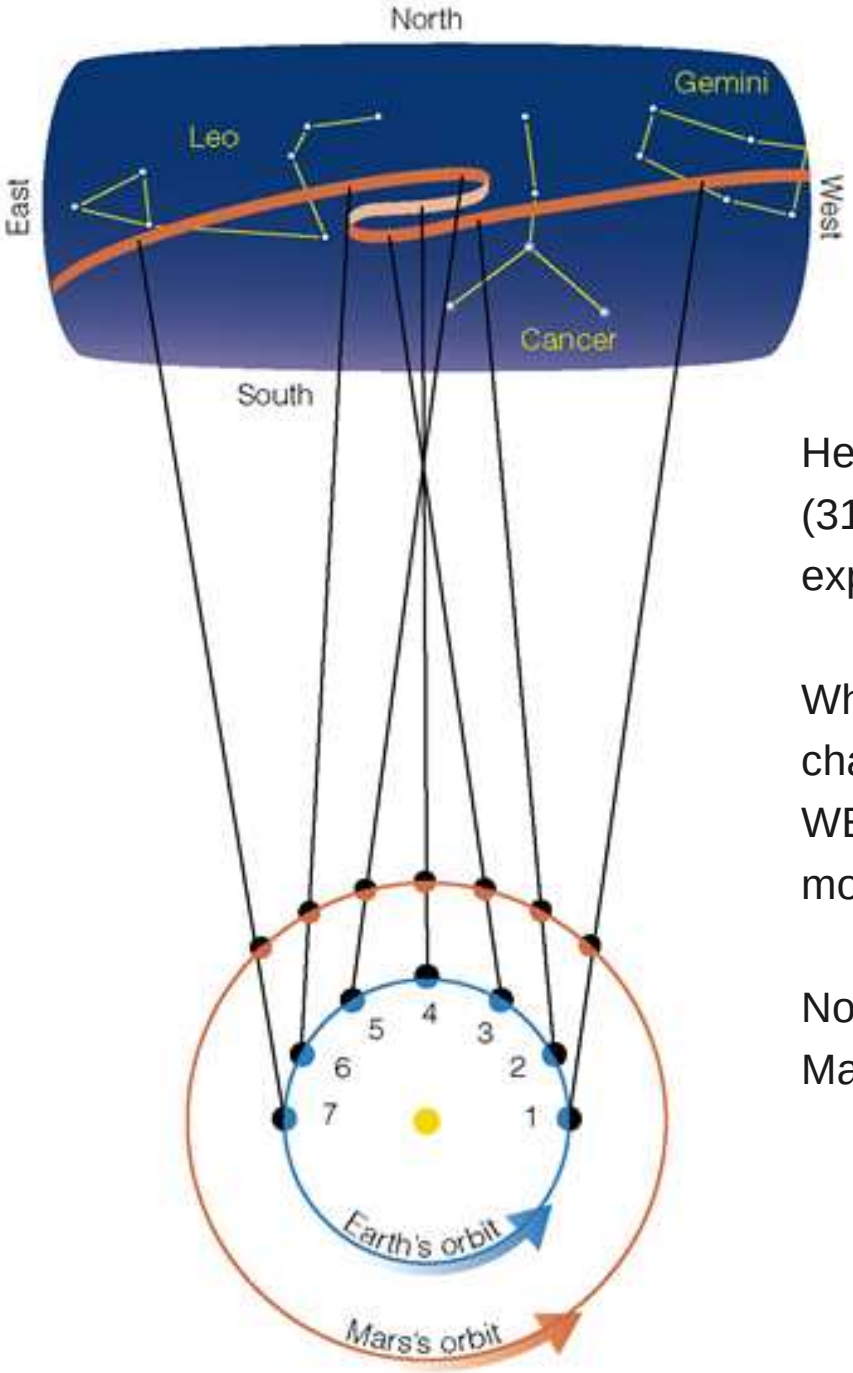
Copernicus (1473-1543)
Polish



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

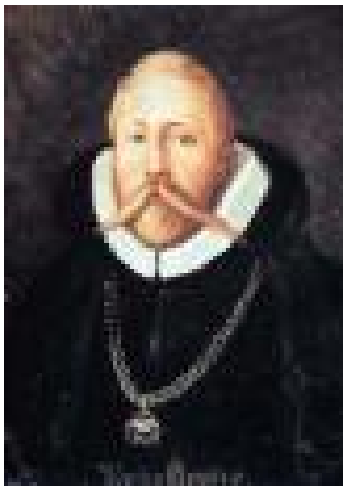
Copernicus's heliocentric model

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?

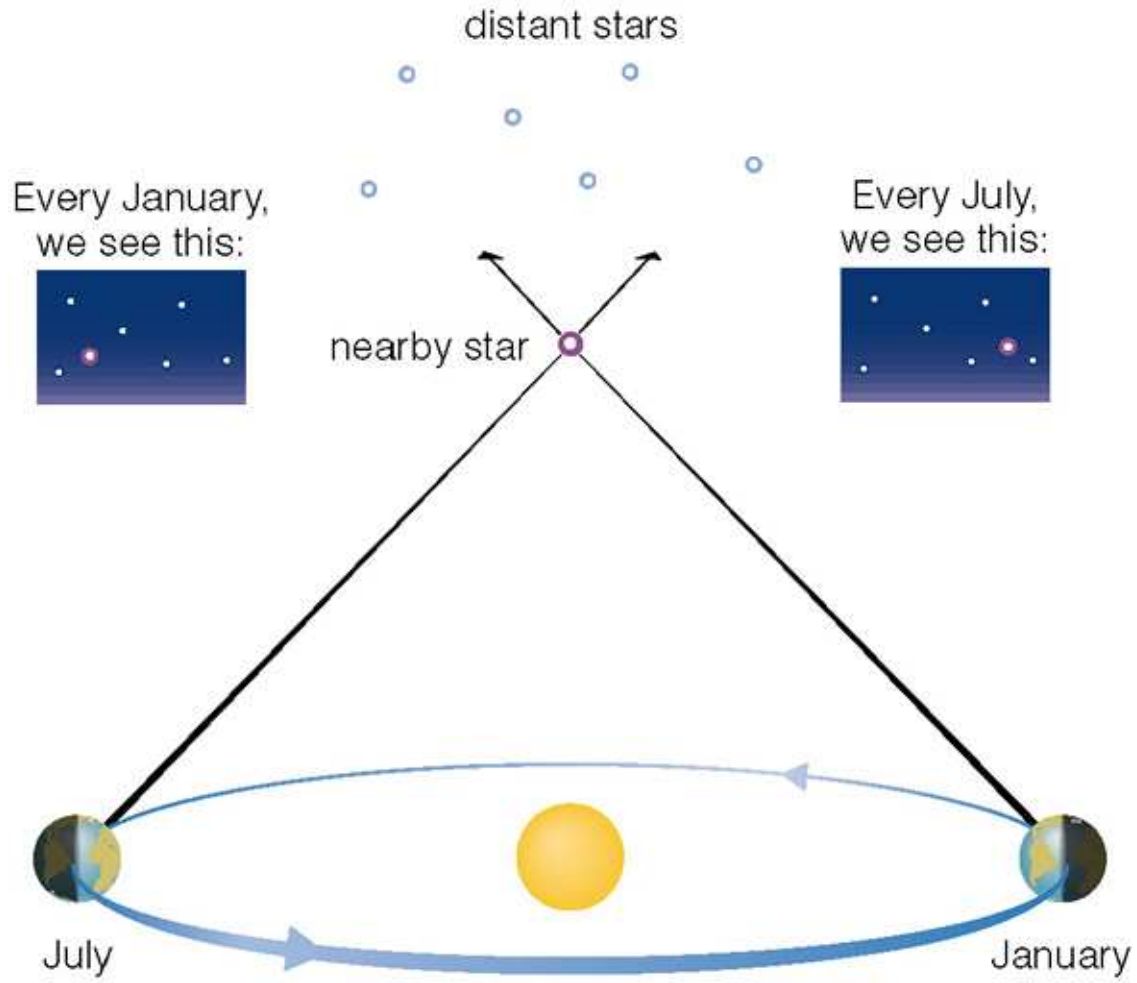
Heliocentric Models and Modern Astronomy



Tycho Brahe (1546-1601)
Danish

Naked-eye observatory of Tycho Brahe funded by King Frederic II

Heliocentric Models and Modern Astronomy



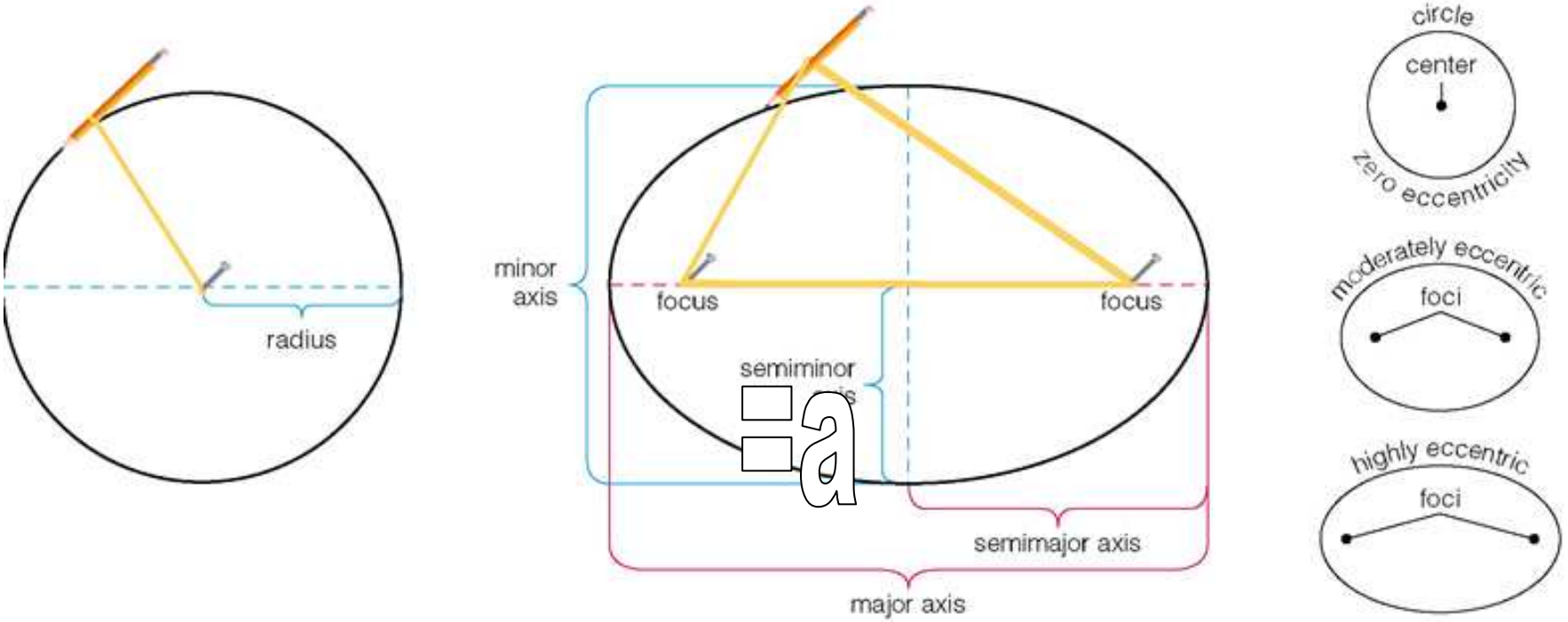
- Stellar parallax = apparent shift of a nearby star against backround of distant stars ,as seen from Earth, due to the motion of Earth about Sun
- Too small to see in naked-eye observation by Tycho

Heliocentric Models and Modern Astronomy

Johannes Kepler (1571-1630)

Gerrman. Started as an assistant to Tycho.Brahe

Kepler's laws of heliocentric planetary motions



Ellipse = Oval defined by 2 points called foci as above

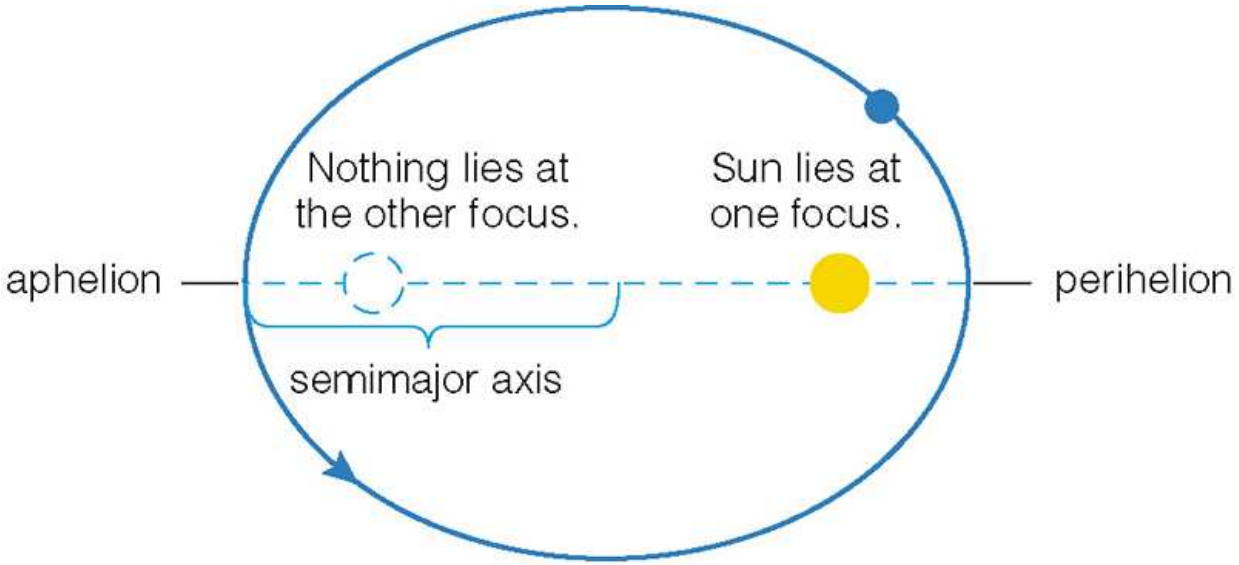
Distance from planet to focus varies; aphelion=furthest , perihelion=closest

Semimajor axis =a Semiminor axis=b . For ellipse b/a<1

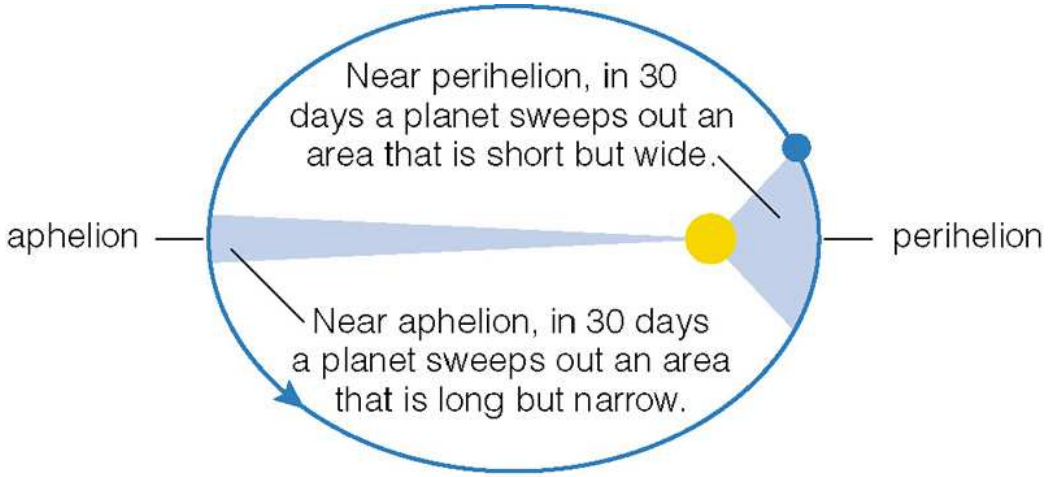
Circle = Defined by one focus or center

b=a=radius of circle; For circle b/a=1

Kepler's laws of heliocentric planetary motions



Law I : Orbit of each planet about the Sun is an ellipse with the Sun at one focus

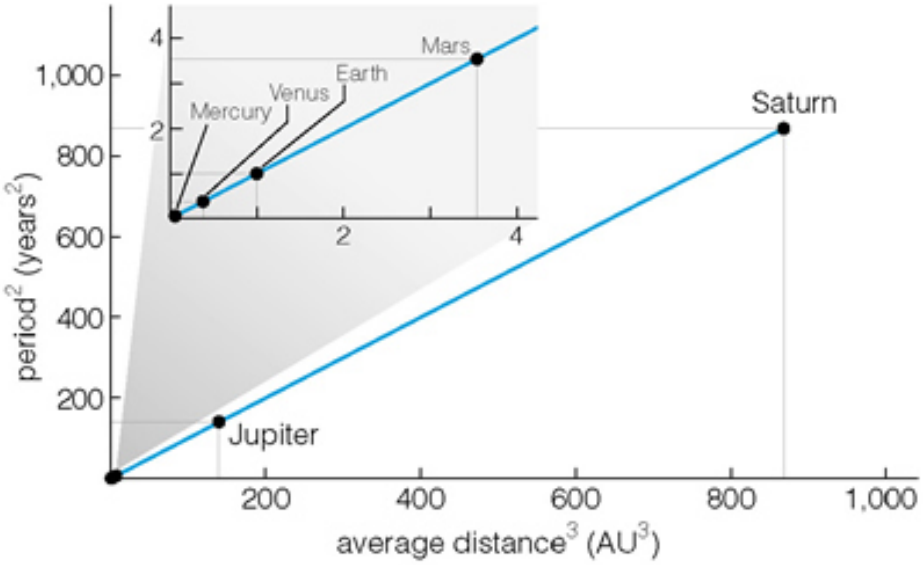


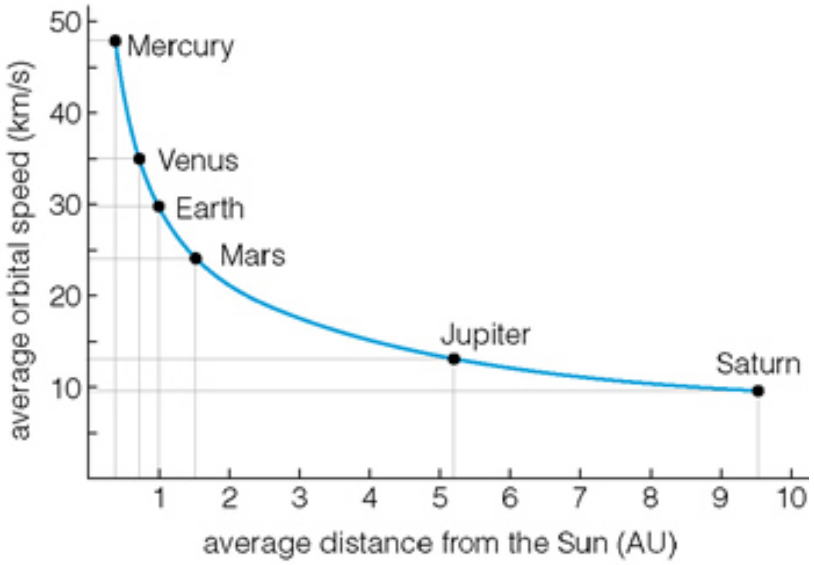
Law II : Line joining Sun and planet sweeps out equal areas in equal areas of time

à planet moves slower when it is farther from Sun

à Max speed at aphelion

Kepler's laws of heliocentric planetary motions





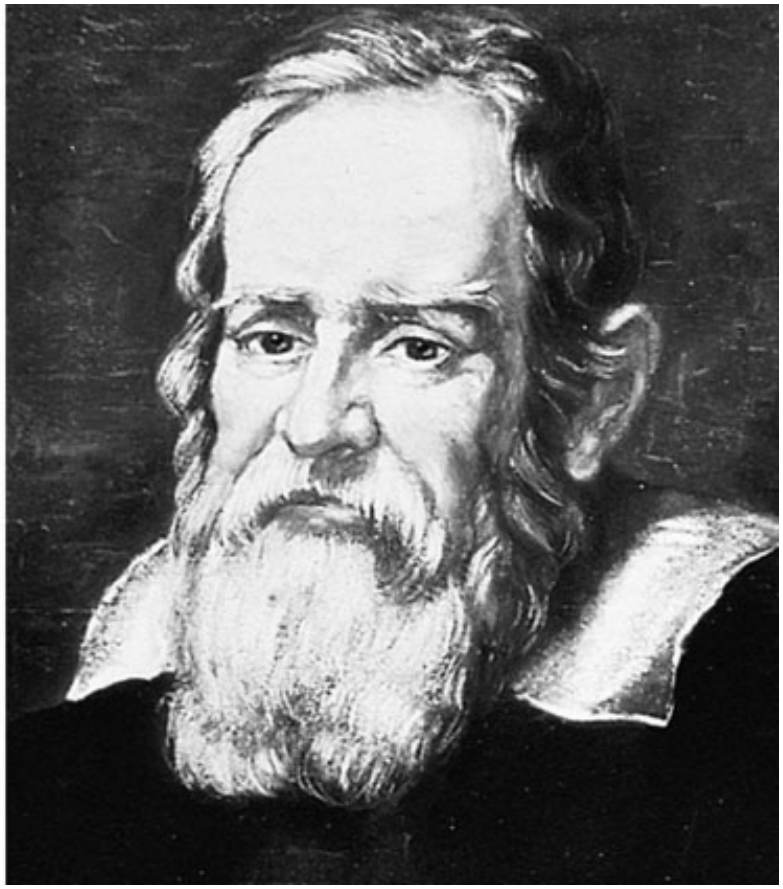
Law III : Planet moves around Sun such that they obey the relationship

(Period P in years)^2 = (Semi-major aixs a in AU) ^{3}

à planet moves slower when it is farther from Sun

à can use observed Period P infer a, and hence mean orbital speed in km/s

Heliocentric Models and Modern Astronomy



Galileo Galilei
1564-1642

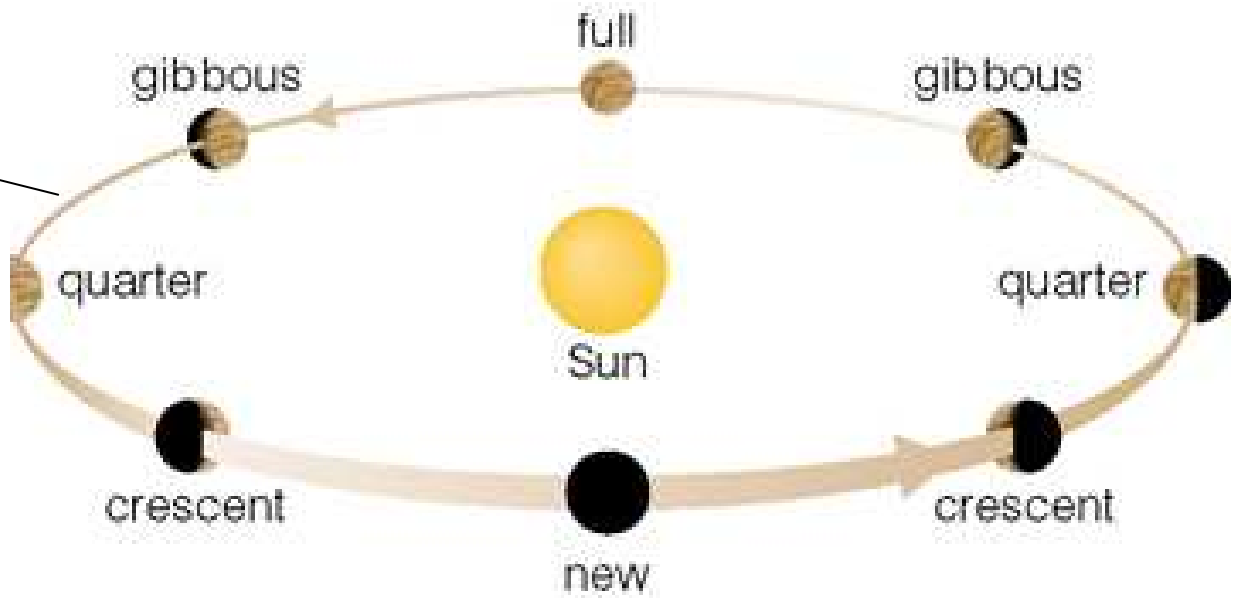
Kepler's laws of heliocentric planetary motions

à consistent will all of Tycho Brahe's data

à but obtained very strong support only after vindication by accurate + unprecedented observations taken by Galileo Galilei with the recently invented telescope

Heliocentric Models and Modern Astronomy

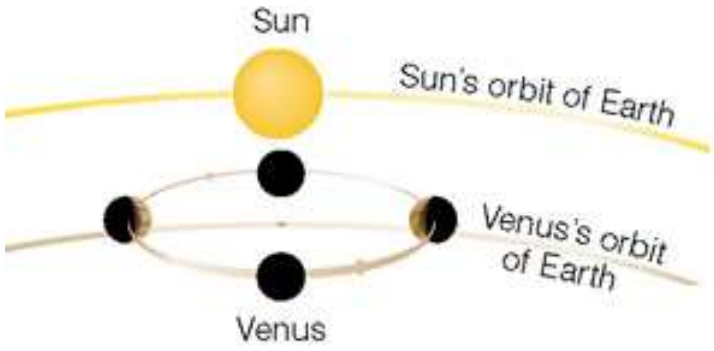
Orbit of Venus
In heliocentric
model



Galileo observed that planet Venus went through all 'lunar-type' phases, including the full phase. This

à shows that Venus must revolve about the Sun (top figure)

à rules out the model where both Venus and Sun revolve about the Earth. In such a case we would see only specific phases of Venus …..? which ones? ….



Orbit of Venus and of Sun in in a geocentric model

Heliocentric Models and Modern Astronomy

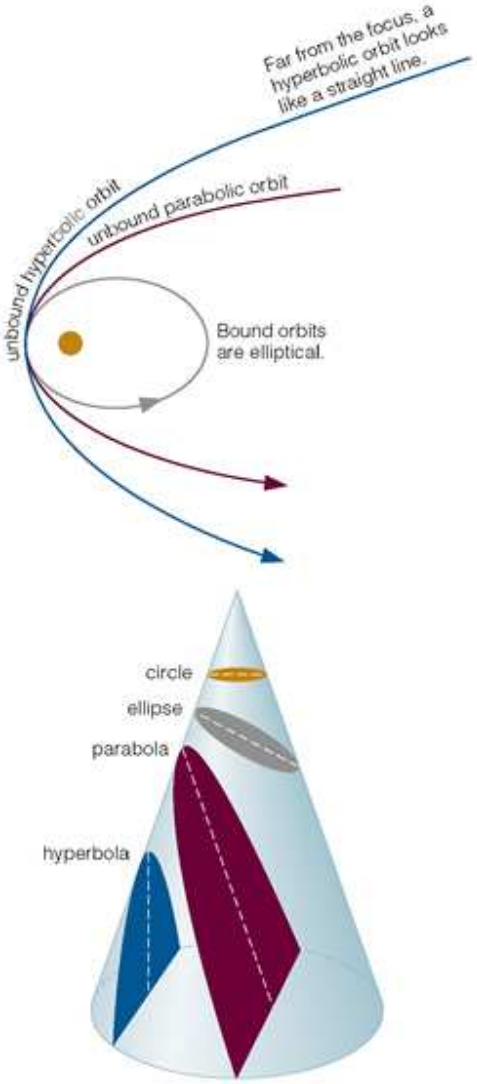
Moon of Jupiter orbit Jupiter and NOT Earth à not everything revolves around E

Imperfections on the surface of the Moon and sunspots on Sun observed by Galileo

à Heavenly bodies are not perfect

à need not move in perfect shapes circles

Newton's law of gravity : Explain + Generalise Kepler's laws



- Orbital paths allowed by law of gravity
  ellipses, hyperbolas, parabolas

- Ellipses = only orbits that are bound

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

- 1642-1747 Newton: Laws of gravity

- 1905-1915 Einstein's Special and General Theory of Relativity

Picture of the Day

Disorder in Stephan's Quintet

Lecture 15: Announcements

-- Quiz 3 grades online

-- Exam 1 and hwk 2 solution set posted outside lecture hall.
Please check solution set first and then come to us

-- Hwk3 and the reading assignment for question 5 are on class website
Due on Tue

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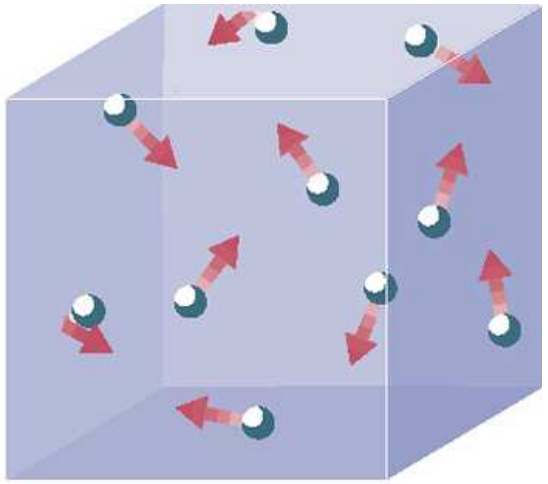
Energy: Forms and Conservation of Energy

Energy and Work

Table 4.1 Energy Comparisons

Item	*Energy (joules)*
Average daytime solar energy striking Earth, per m^2 per second	1.3×10^3
Energy released by metabolism of one average candy bar	1×10^6
Energy needed for 1 hour of walking (adult)	1×10^6
Kinetic energy of average car traveling at 60 mi/hr	1×10^6
Daily energy needs of average adult	1×10^7
Energy released by burning 1 liter of oil	1.2×10^7
Energy released by fission of 1 kg of uranium-235	5.6×10^{13}
Energy released by fusion of hydrogen in 1 liter of water	7×10^{13}
Energy released by 1-megaton H-bomb	5×10^{15}
Energy released by major earthquake (magnitude 8.0)	2.5×10^{16}
Annual U.S. energy consumption	10^{20}
Annual energy generation of Sun	10^{34}
Energy released by supernova (explosion of a star)	10^{44}–10^{46}

Forms of Energy



Kinetic energy

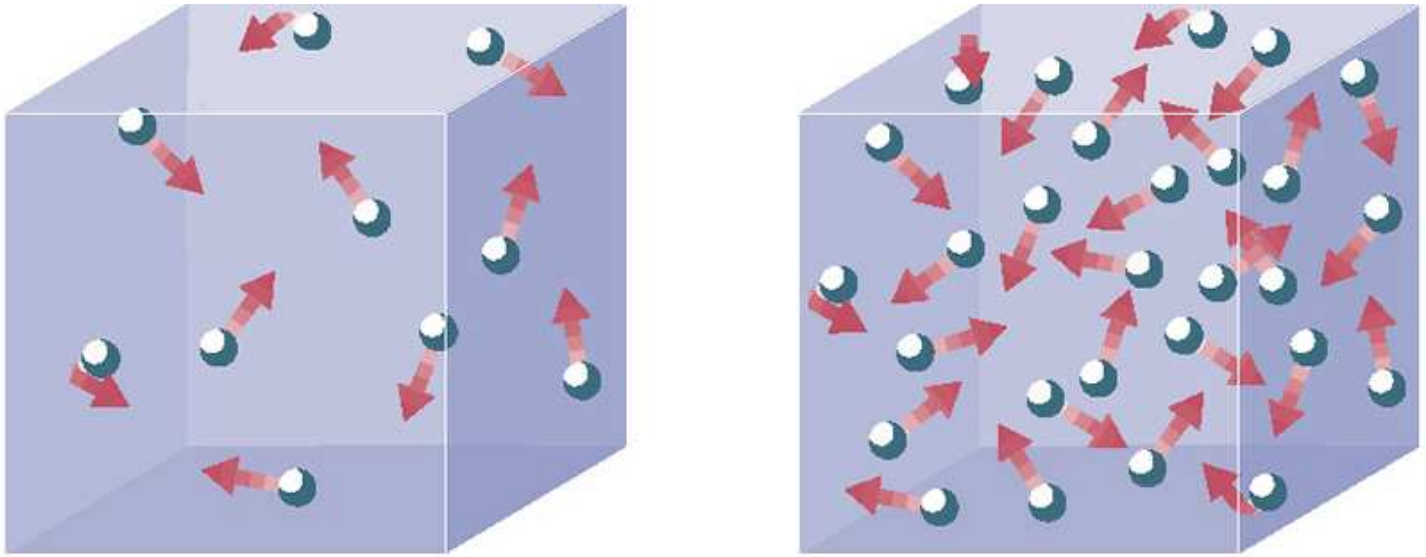
Thermal Energy

Radiative energy (light)

Gravitational potential energy

Sound energy

Thermal Energy



Thermal Energy of each particle depends on temperature T

Total thermal energy of 2 blocks of matter having same volume is larger for block having more particles à higher density

Equivalence of Mass and Energy; $E=Mc^2$

- Energy E stored in Mass M = Mc^2
  (Einstein)

- $E < 0.007\ Mc^2$ from fission of Ura. or Plu.

  à Hiroshima bomb (1945): fission of 1 g of Uranium. E released equivalent to that of 20 kilo-tons of TNT

- $E = 0.007\ Mc^2$ from Hydrogen fusion

  à Hydrogen bomb in 1952

- $E = 0.1\ Mc^2$ = energy relased (X rays, etc) as mass M falls onto the accretion disk of a black hole