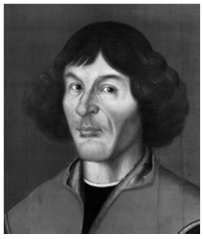
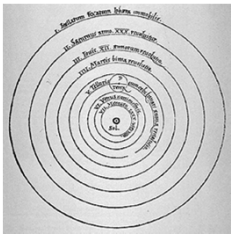
Lecture 4:

The Copernican Revolution





Astronomy 141 – Winter 2012

The lecture will discuss the Copernican Revolution.

Modern science was born out of an effort over many centuries to understand the motions of celestial bodies.

Two competing models were proposed:
- Geocentric (earth-centered) and
- Heliocentric (Sun-centered).

The final success of the heliocentric model relied on crucial philosophical insights and technological advances.

The motions of celestial bodies visible to the naked eye are mostly regular and repeatable.

The stars rise in the east and set in the west daily

The Sun rises & sets daily, and makes an eastward circuit relative to the stars once a year.

The Moon rises & sets daily, and makes an eastward circuit relative to the stars once a month.

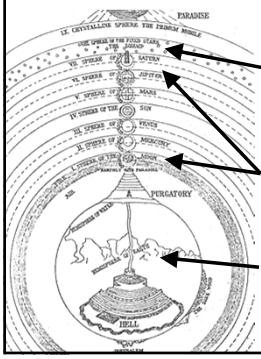
Planetary motions are much more complex, showing occasional retrograde motion.

Planets rise and set daily, and move generally eastward relative to the stars at varying speeds.

Mars during 2005/6 Retrograde

But, they occasionally stop, move westward (or retrograde), then stop again and resume moving eastward.

For 2000 years, a geocentric model for the universe was widely assumed.



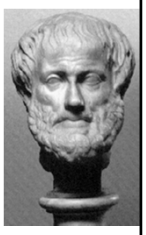
Stars affixed to a Celestial Sphere

Moon, Sun, planets, between the Earth & stars

Spherical Earth at center of the Universe

Aristotle (384-322 BC) argued for a geocentric model on physical grounds.

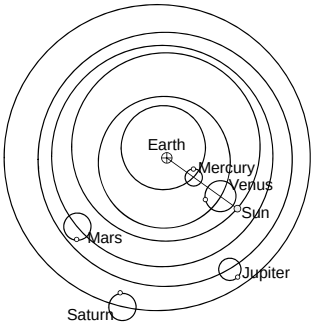
Earth was fixed and unmoving at the center because it is was too big to move, including rotation.



The Sun, Moon, Planets and Stars are afixed to crystalline spheres in *uniform circular motion*.

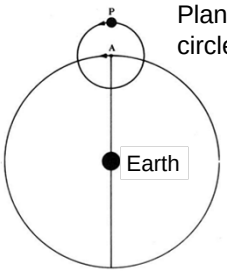
The combination of perfect motions produces the net retrograde and non-uniform motions observed.

The ultimate Geocentric System was formulated Claudius Ptolemy around 150 AD.



This model was to prevail for nearly 1500 years.

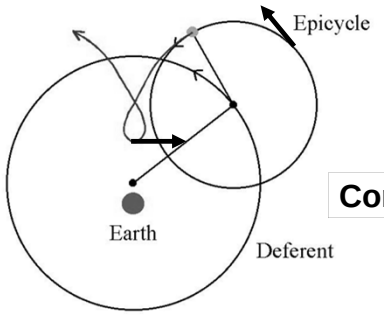
Ptolemy's explanation of retrograde motion:



Planet (P) moves in a small circle called the epicycle.

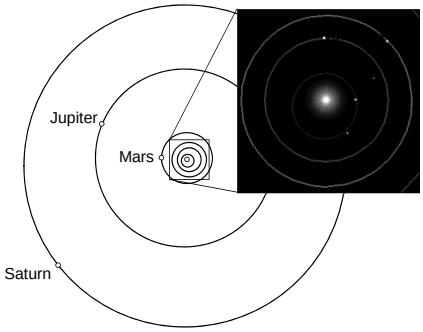
Center of epicycle (A) moves in a large circle called the deferent.

Combination of small and large circles creates "loop-the-loop" retrograde motion.



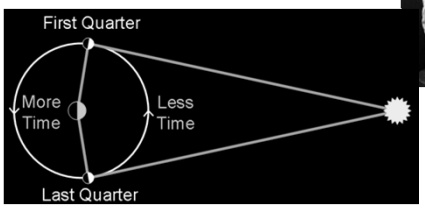
Complex!

Heliocentric Models have the planets, including Earth, in motion around a central Sun.



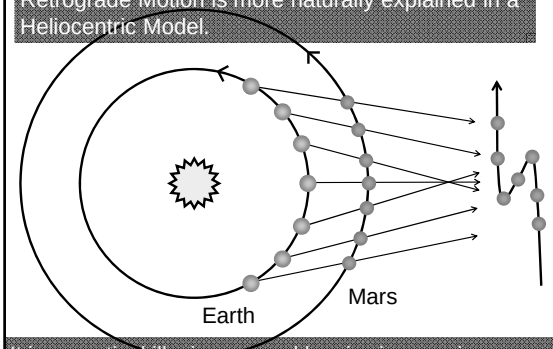
Aristarchus of Samos (310-230BC) proposed the first known Heliocentric model.

Showed geometrically that the Sun was 20× further away than the Moon.



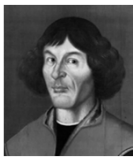
Makes the Sun much bigger than the Earth!

Retrograde Motion is more naturally explained in a Heliocentric Model.

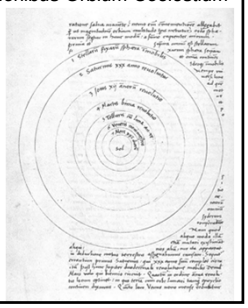


It is an optical illusion caused by viewing moving planets viewed from a moving Earth.

Nicolaus Copernicus (1473-1543) revived the Heliocentric system in the 16th century after 18 centuries of neglect.



De Revolutionibus Orbium Coelestium (1543)



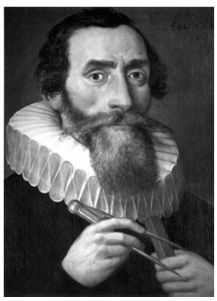
Still clinged to Aristotle's belief in uniform circular motion.

Had to use epicycles to get the motions correct (fine tuning).

English astronomer Thomas Digges (1546-1595) discarded the idea of a "Celestial Sphere".

Stars are at different distances from the Sun. Nearby stars are bright; more distant stars are dimmer; very distant stars are too dim to be seen.

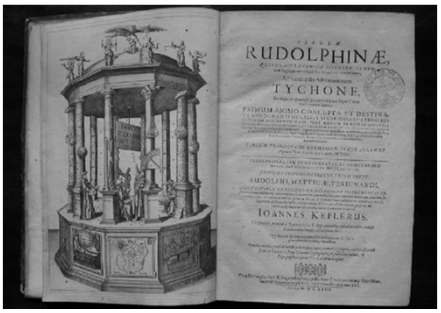
Johannes Kepler (1571-1630) took Copernicus' ideas further and discarded epicycles.



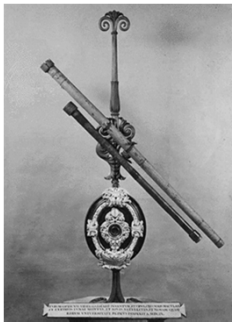
Kepler's laws of planetary motion state that planets go around the Sun on ellipses rather than circles.

They move with changing speeds rather than at constant speeds.

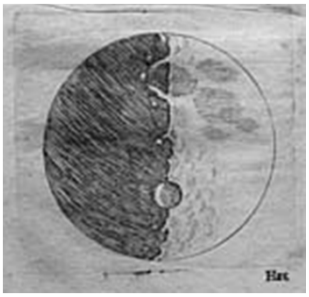
Kepler's laws of planetary motion made much more accurate predictions of planetary positions, contributing to the triumph of Heliocentric Models.



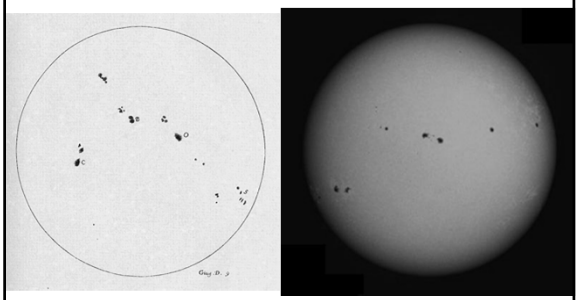
Galileo Galilei (1564-1642) made crucial discoveries with the newly invented telescope



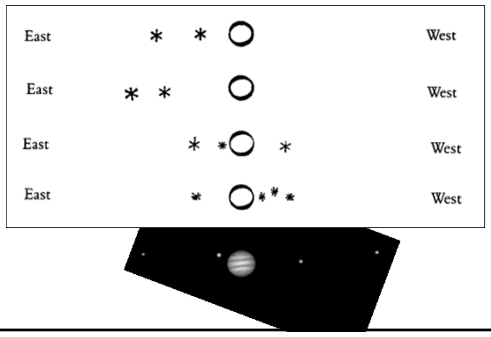
The observation of craters and mountains on the Moon showed that it had terrain like the Earth.



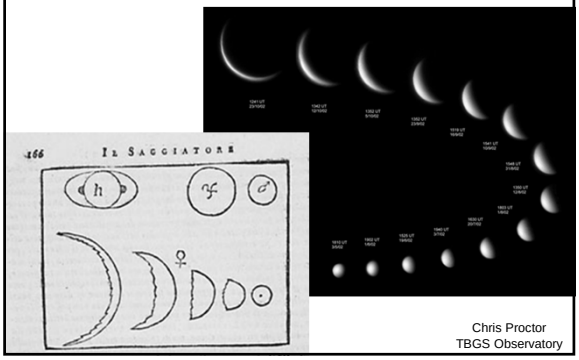
The observation of sunspots showed that the Sun was imperfect and rotating slowly!



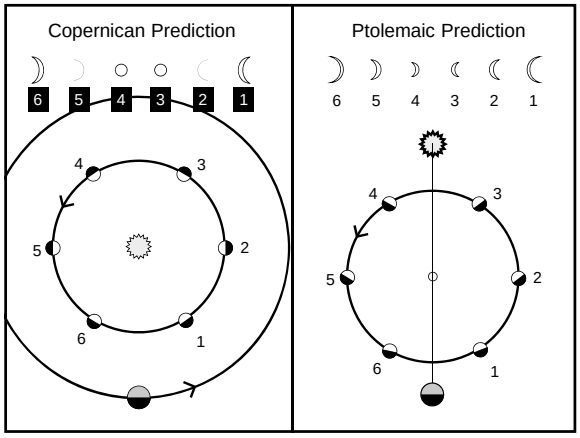
The discovery of four moons of Jupiter showed that the Earth was not the only center of motion…



The Phases of Venus demonstrated decisively that Venus orbits the Sun.



Chris Proctor
TBGS Observatory



The Copernican Revolution gives us an important framework for understanding the Universe.

We do not occupy a special or privileged place in the Universe.

The Universe and everything in it can be understood and predicted using a set of basic physical laws ("rules").

The entire Universe obeys the same physical laws everywhere (and at all times).