Astronomy 100

Section 2– MWF 1200-1300

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Office Hours:

MTF 10:30-11:30 a.m. or by appointment

- Homework #1 is due Friday, 11:50 a.m.!!!!!
- Planetarium shows are getting filled. The 18th is the last date.
- Solar Observing starts next Monday!
- Nighttime observing starts in 2 weeks.

Outline

- Solar Eclipses– recap
- Dance of the Planets– Planetary motion
- Prograde and Retrograde motion
- Theories of Planetary motion
  - Geocentric
  - Heliocentric
- Ptolemy and his geocentric model
- Copernicus and his heliocentric model

Total Lunar Eclipse– Time Lapse

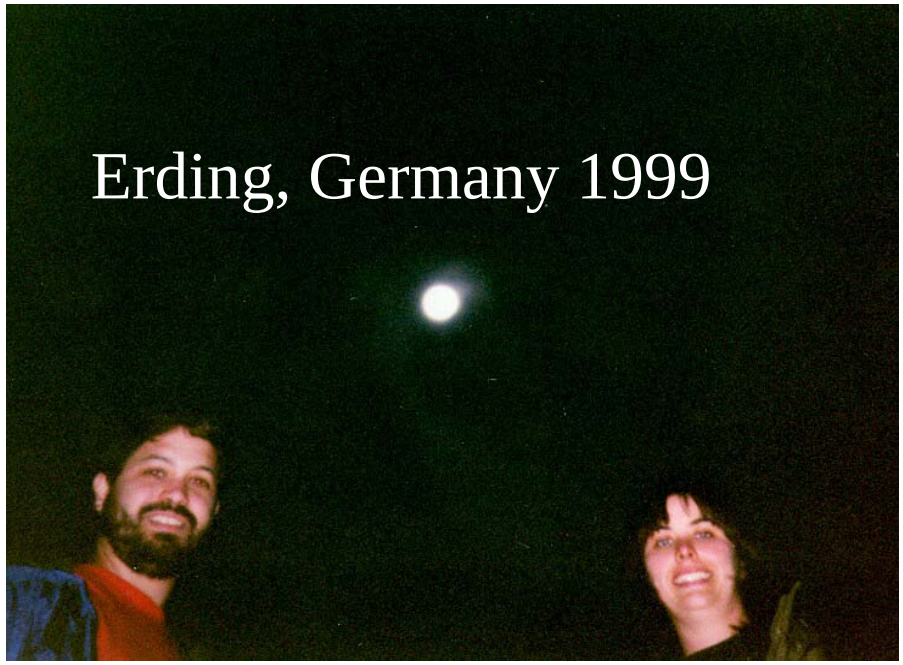
- Occurs when the Moon passes through Earth's umbra completely.

- Occur roughly twice a year, and last for about an hour or two.
- Can be seen by anyone experiencing night during the lunar eclipse.

http://www.mreclipse.com/LEphoto/TLE20001/T00sequence1w.JPG

Solar Eclipses

- Occur when the Moon casts a shadow on the Earth.
- Only possible because the Moon and Sun are approximately the same size as seen from Earth, around ½ a degree.
- Occur roughly twice a year, and last only a matter of minutes.
- Viewable only in a very small band of area across the Earth (about 270 km in width).



Digitally Added Picture

http://antwrp.gsfc.nasa.gov/apod/image/9909/corona99_espanek.jpg

An Eclipse Movie

http://www.saxton.org/eclipse/eclipse.mov

Annular Eclipse

There is a small difference (a few percent) in the size of the Moon, due to a slightly elliptical orbit. When the Moon is at its farthest, a total eclipse is not possible. An annular eclipse is seen more often than total eclipses.

http://antwrp.gsfc.nasa.gov/apod/image/9808/annulareclipse_staiger_big.jpg

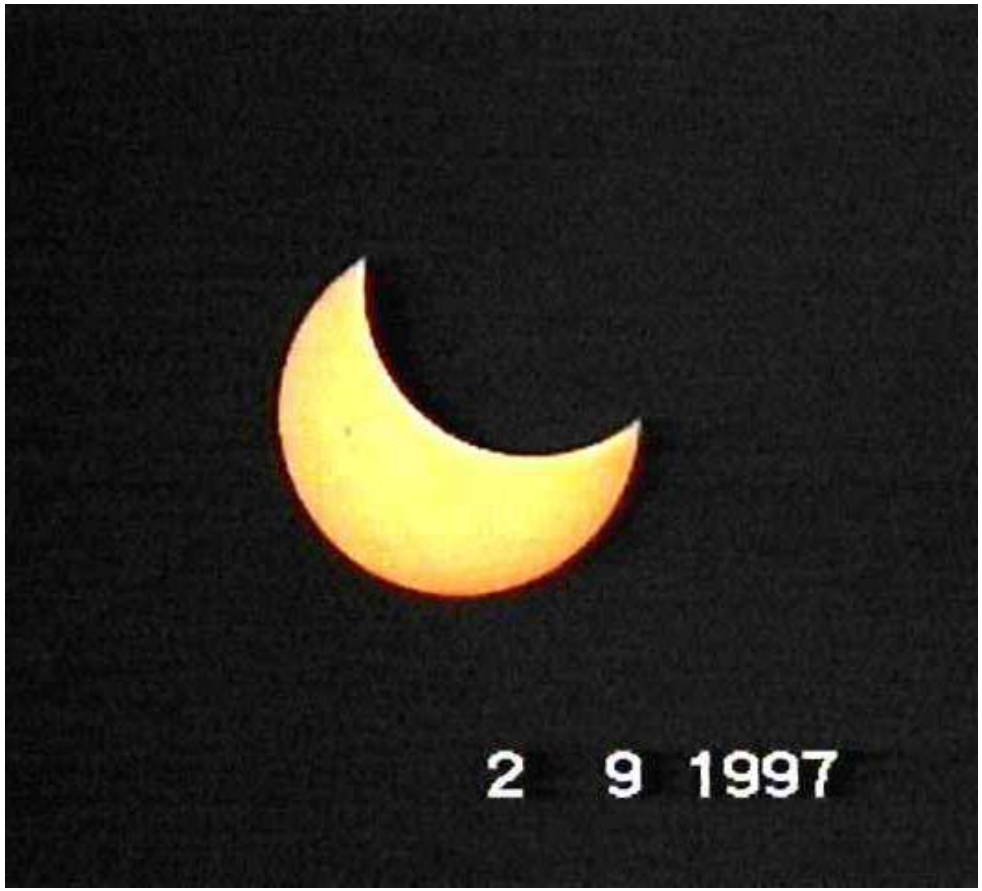
Apparent Moon Sizes

Perigee **Apogee**

http://www.fourmilab.ch/earthview/moon_ap_per.html

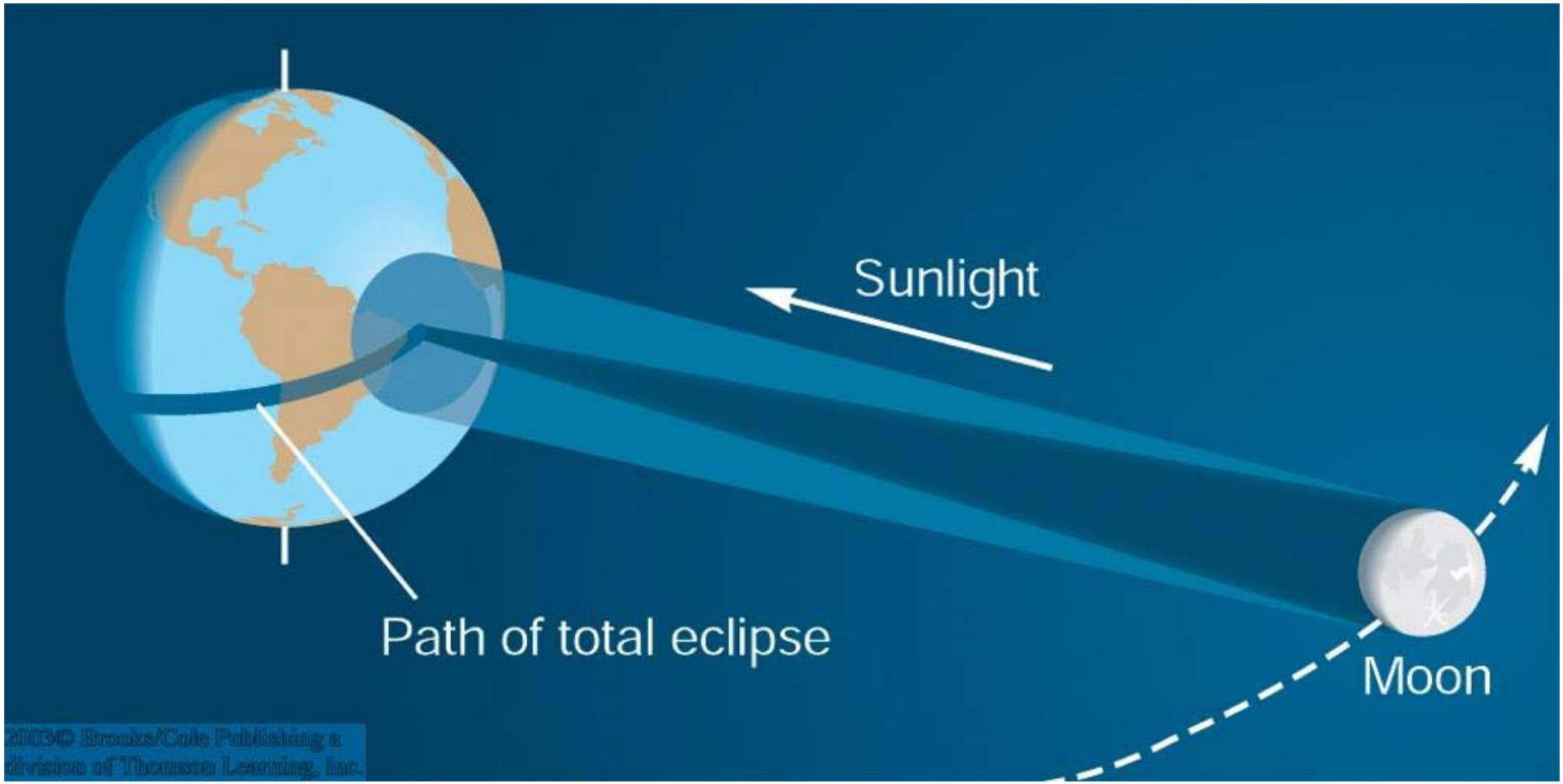
Partial Eclipse

Like the Earth's shadow for a lunar eclipse, the Moon's shadow has 2 parts, the umbra and penumbra. If you are in the penumbra, you only see a partial eclipse. Even if people a few miles away see a total eclipse.



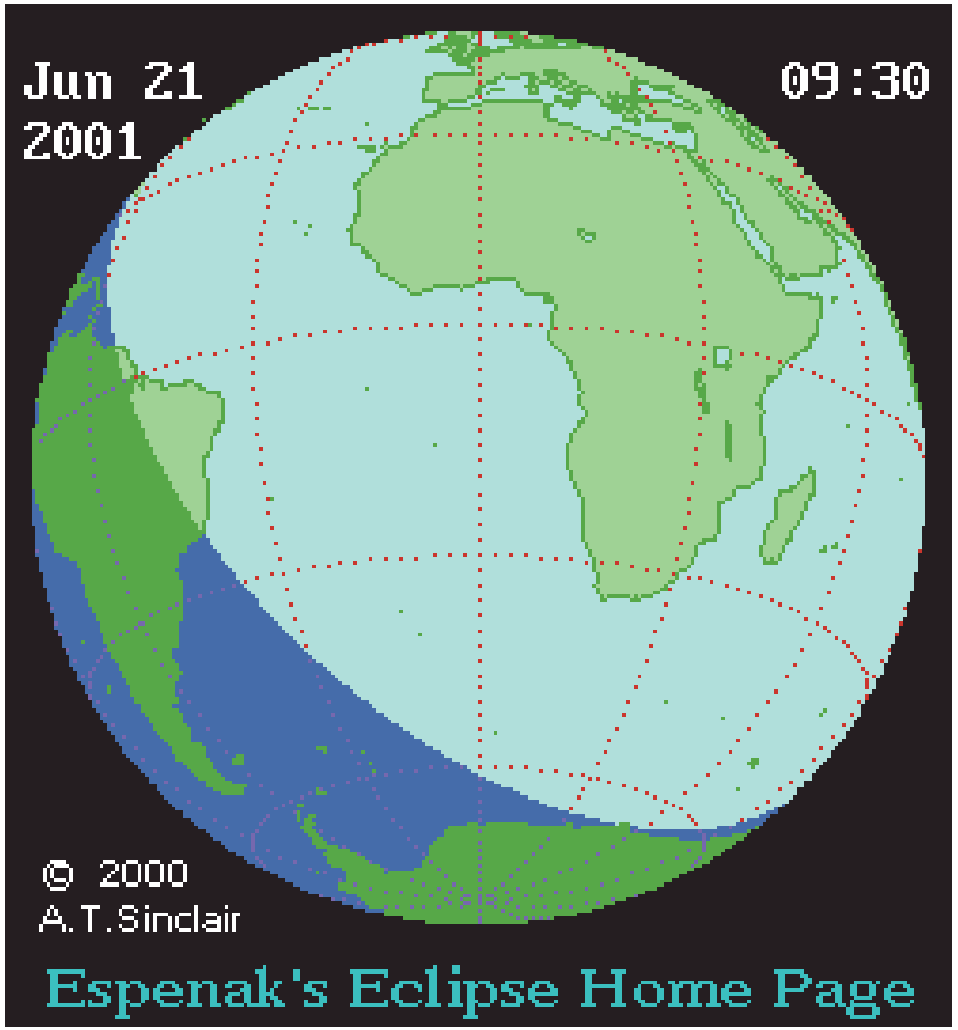
http://antwrp.gsfc.nasa.gov/apod/image/9709/soleclipse1_staiger_big.jpg

Moon's Shadow



Path of the Eclipse

Shadow of the Moon races across globe.

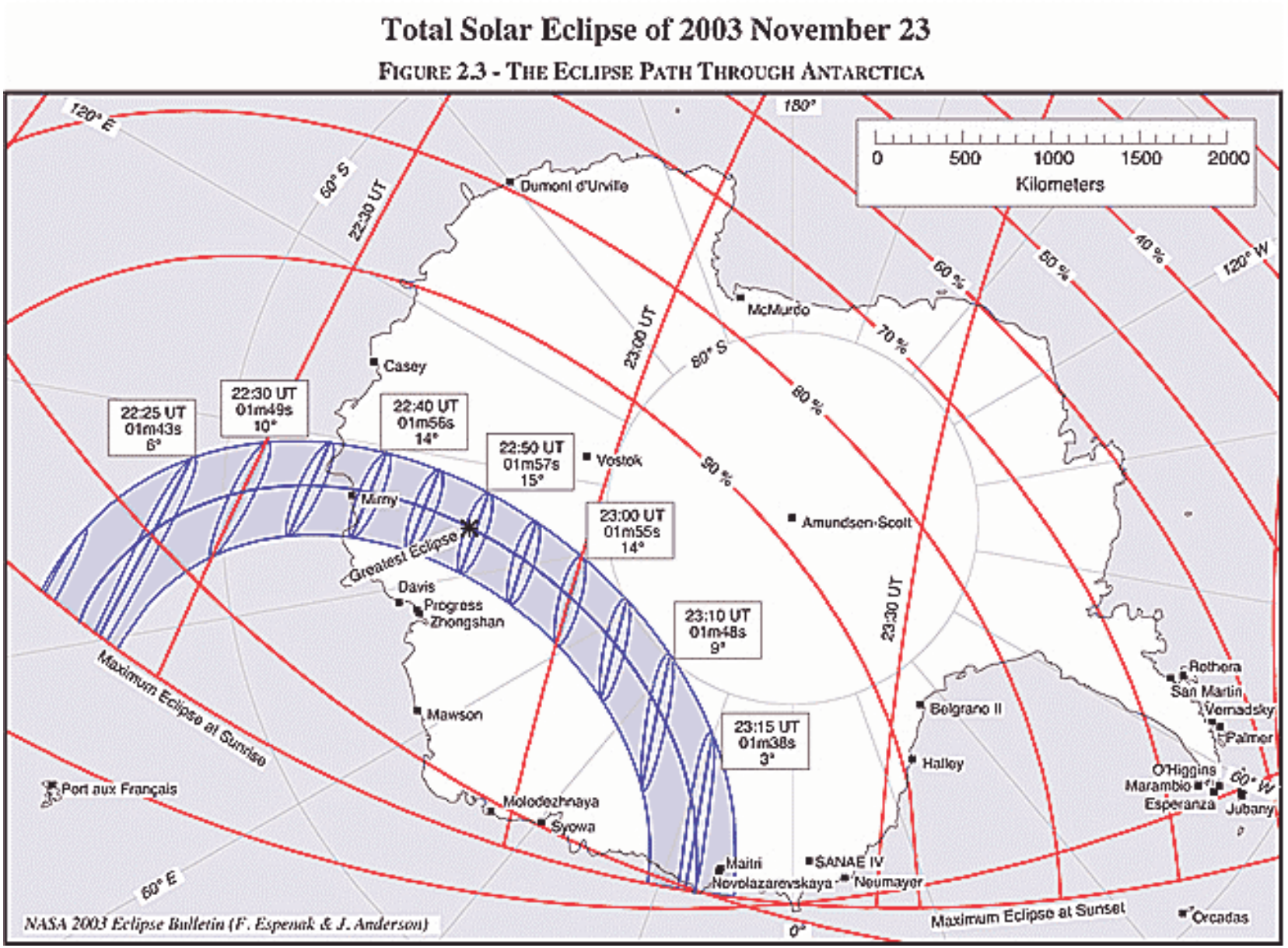


http://sunearth.gsfc.nasa.gov/eclipse/TSE2001/T01animate.html

Solar Eclipse Seen from Space

http://antwrp.gsfc.nasa.gov/apod/ap990830.html

Next Eclipse



http://umbra.nascom.nasa.gov/eclipse/2003/figures/figure_2.3.gif

Very common for a Lunar Eclipse to occur also.

We can see a total lunar eclipse November 9th, around midnight. Should last for about 24 minutes.

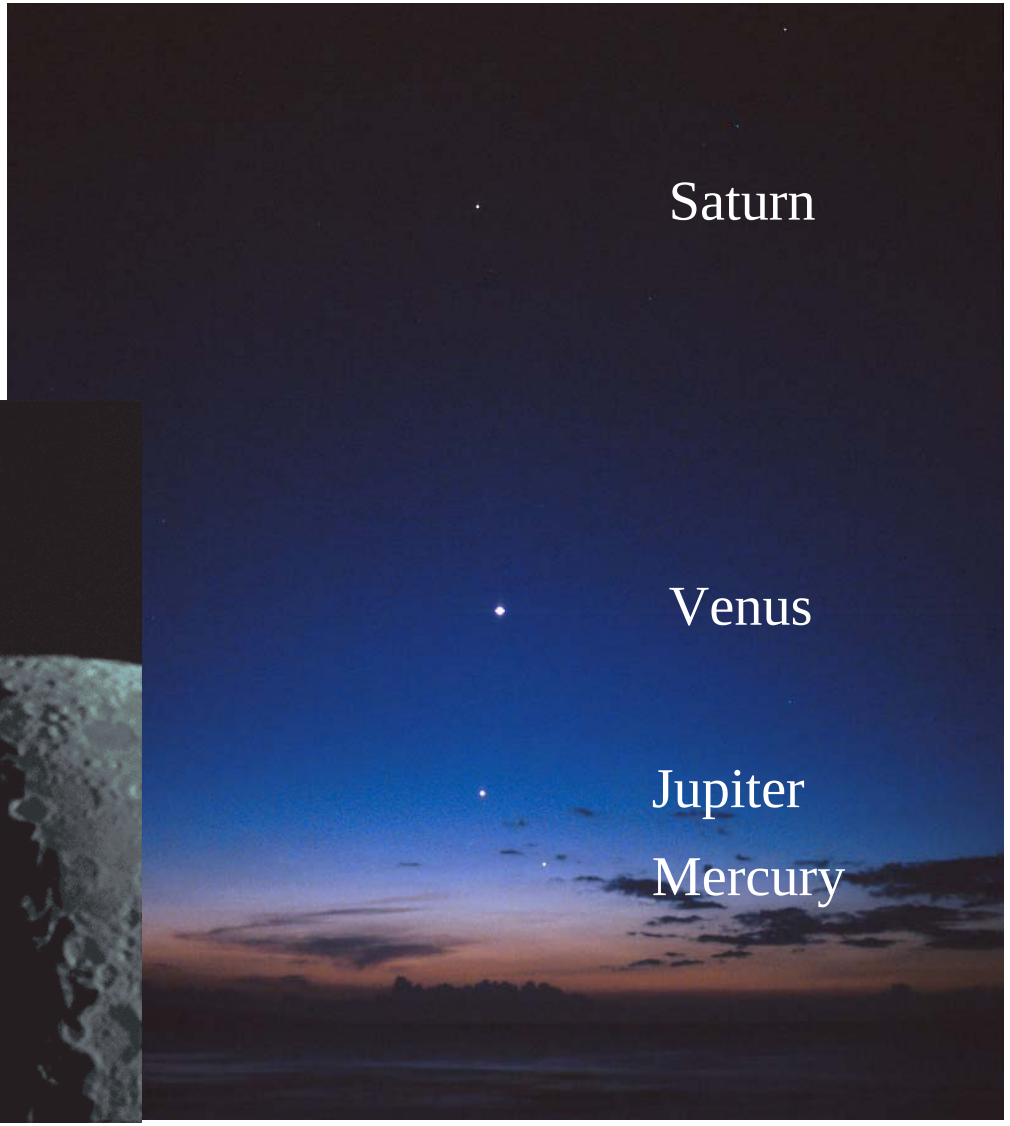
Eclipses

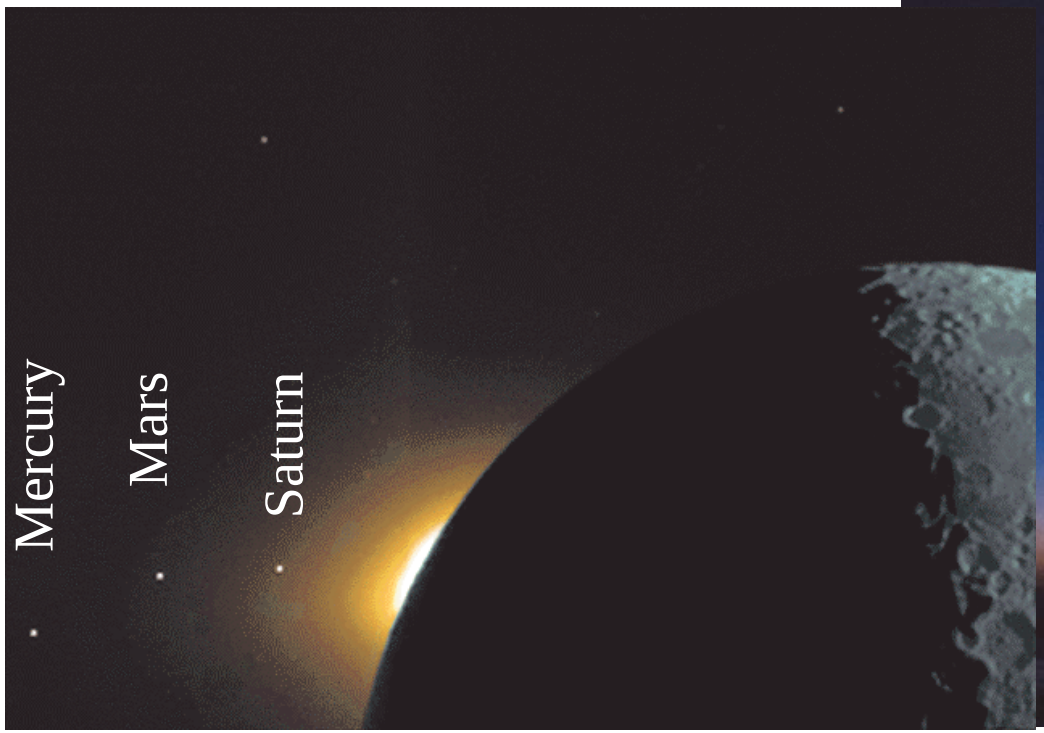
- Lunar: due to the Moon passing through Earth's shadow.
- Solar: due to the Earth passing through the Moon's shadow.

- Occur roughly every six months due to the inclination of the Moon's orbit around the Earth.

Dance of the Planets

Planets also orbit near the Ecliptic





http://antwrp.gsfc.nasa.gov/apod/ap990325.html

http://antwrp.gsfc.nasa.gov/apod/ap001014.html

Planetary Motion

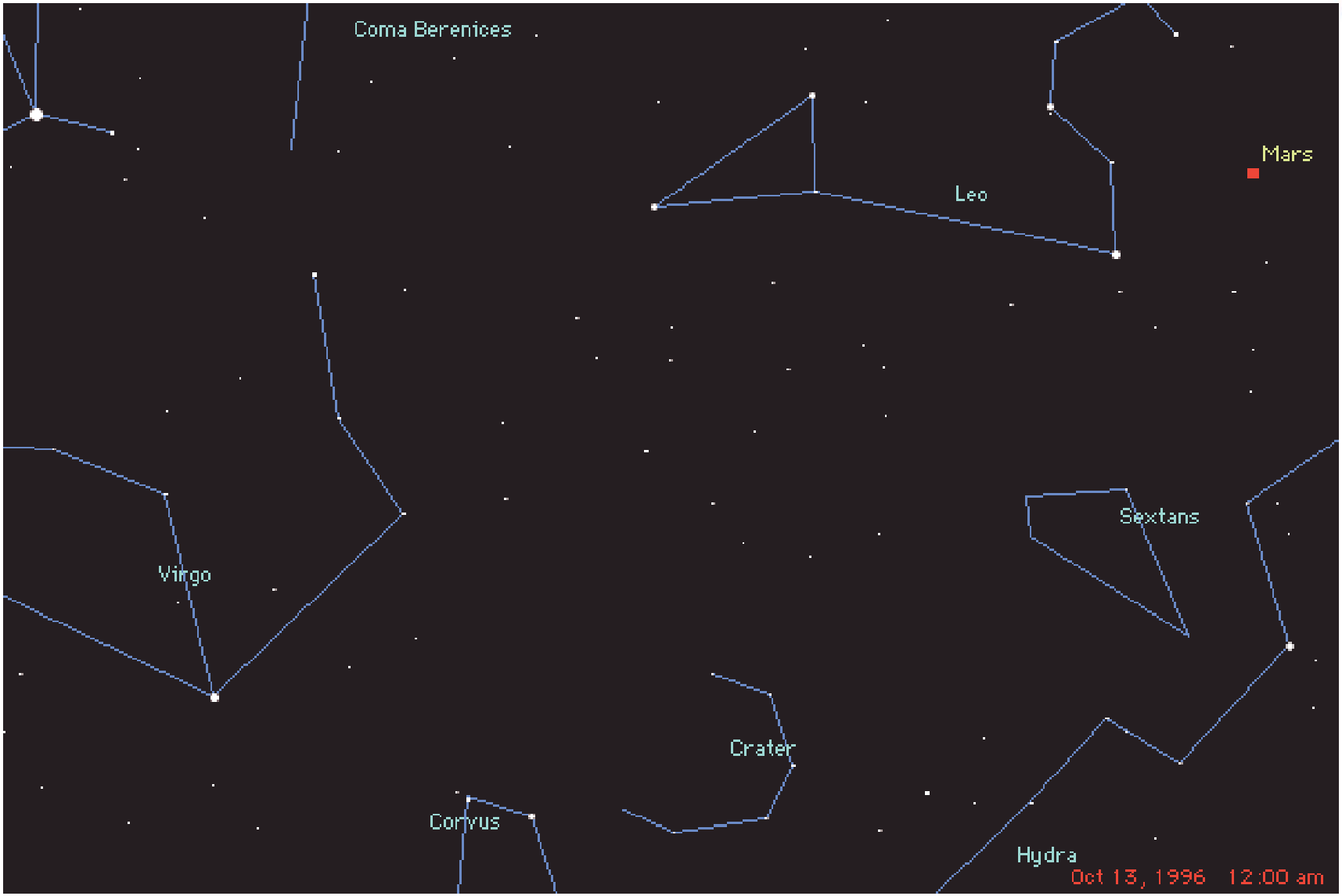
- The word “planet” derives from the Greek word for wanderers.
- On a single night planets will rise with stars and constellations and move from East to West.
- However, over time, how does planet motion map on the sky?

Mars Motion

If every night you compared Mars to the Celestial Sphere what does Mars do with respect to the Stars?

1. As the Earth orbits the Sun, the motion of Mars sometimes goes backwards.
2. As Mars is so far away, it's movement is not noticeable over 1 year.
3. Mars, like the Sun, follows the ecliptic.

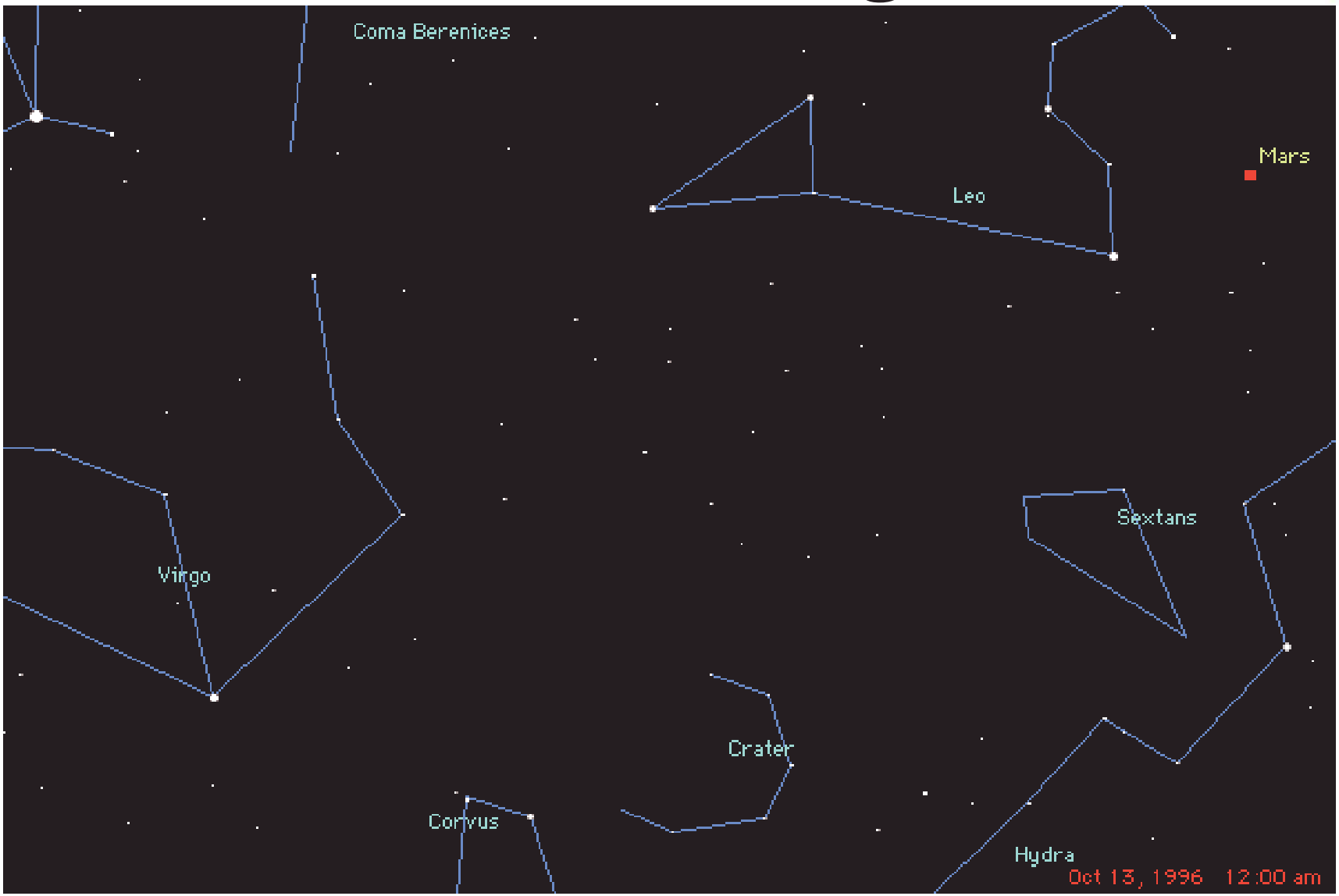
Mars Moves


Coma Berenices
Mars
Leo
Sextans
Virgo
Crater
Corvus
Hydra
Oct 13, 1996 12:00 am

Motions of Planets

- So, over time the planets seem to move along the ecliptic from west to east over long time periods.
  - This is called ***prograde*** motion
- But once in a while, a planet appears to stop and reverses direction
  - Reverse direction is called ***retrograde*** motion (east to west).
- Planets move counter-clockwise (looking down at the north pole)

Let's see that again

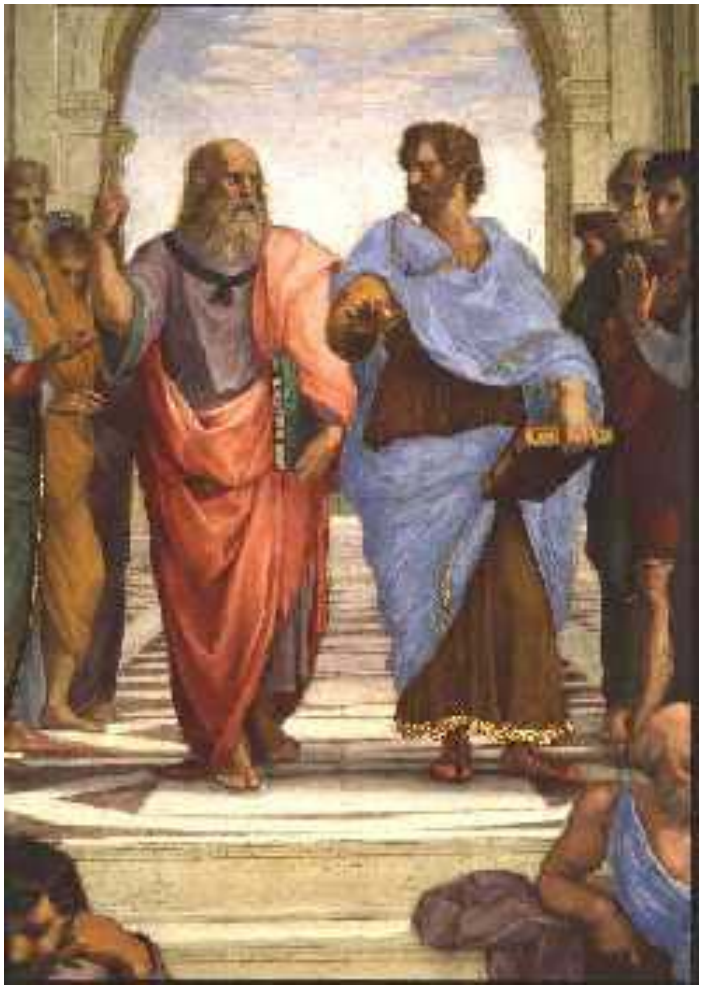


E A S T

W E S T

Greek Astronomy

- Greeks were excellent Astronomers
  - Cataloged star positions, brightness
  - systematic, quantitative observations
- They observed that the stars, Sun, and planets revolved around the Earth.
- So Earth is center of Universe- ***geocentric cosmology***



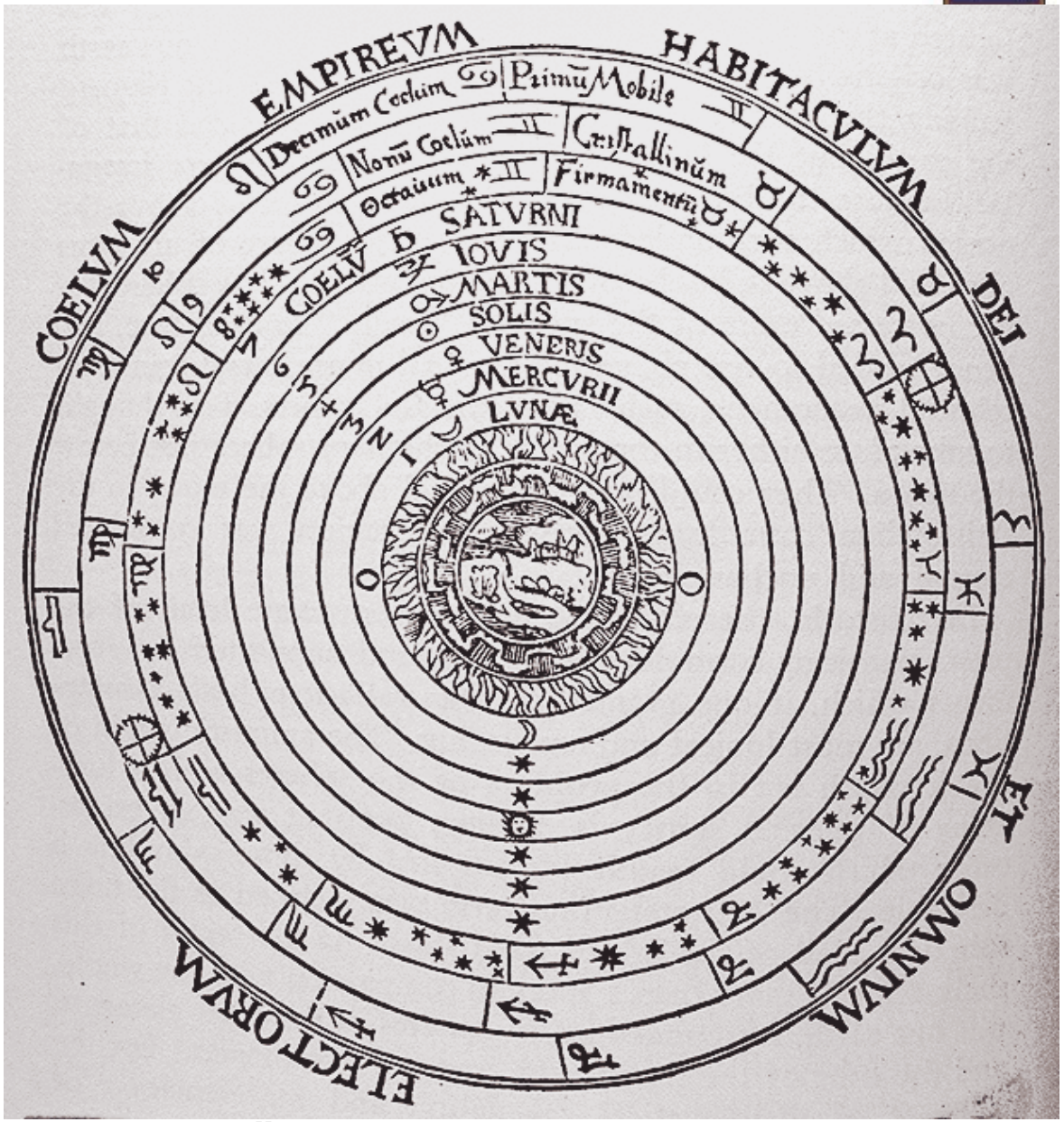
How can we explain the Planet motion?

- For most of Western Civilization it was believed that we lived in a ***geocentric cosmology***.
  - Earth centered (everything else revolved around us)
- Although a ***heliocentric cosmology*** had been introduced around 280 BC
  - Sun centered (everything revolves around sun)

How can we explain the Planet motion?

But for a ***geocentric cosmology*** you can't easily explain the retrograde motion of the planets.

Note: perfect circles

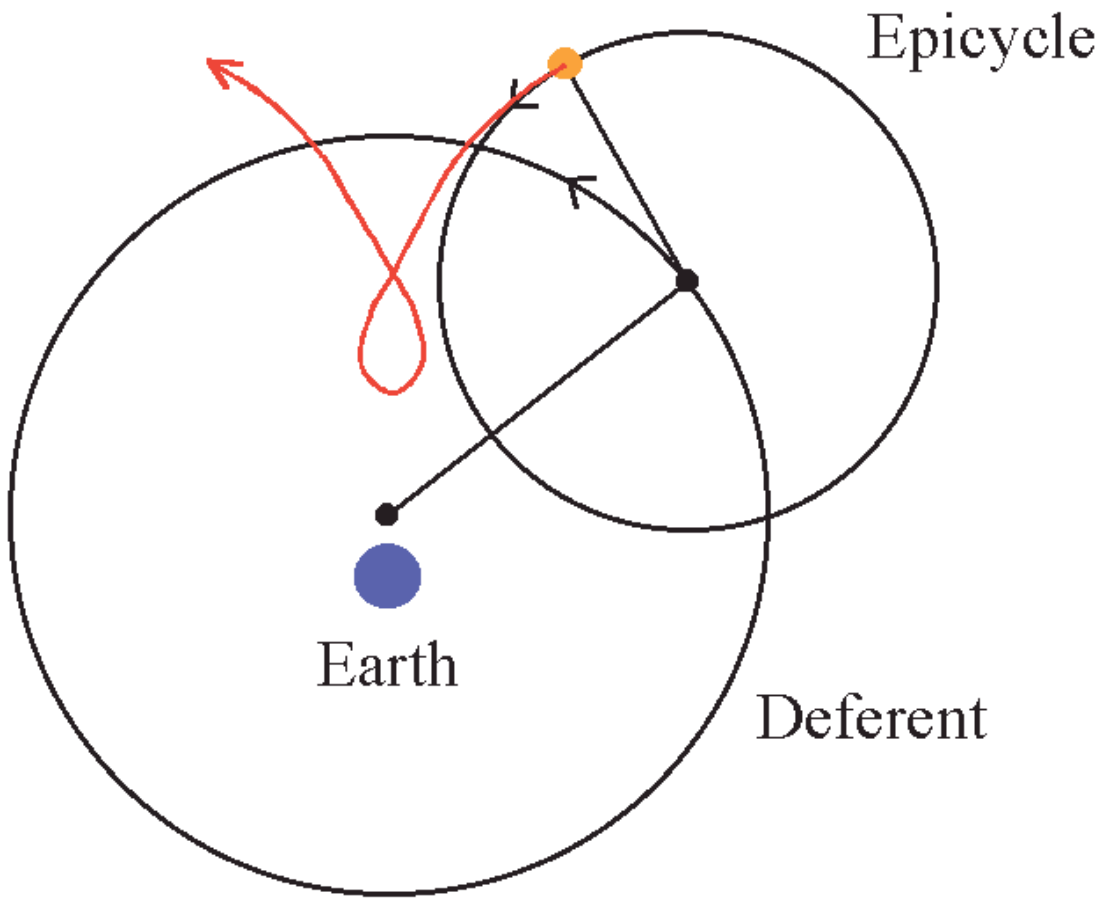


Ptolemy (140 AD: `p` is silent)

Took geocentric model with uniform circular motion to introduce the Ptolemaic system, or model, of the Solar System that explained retrograde motion

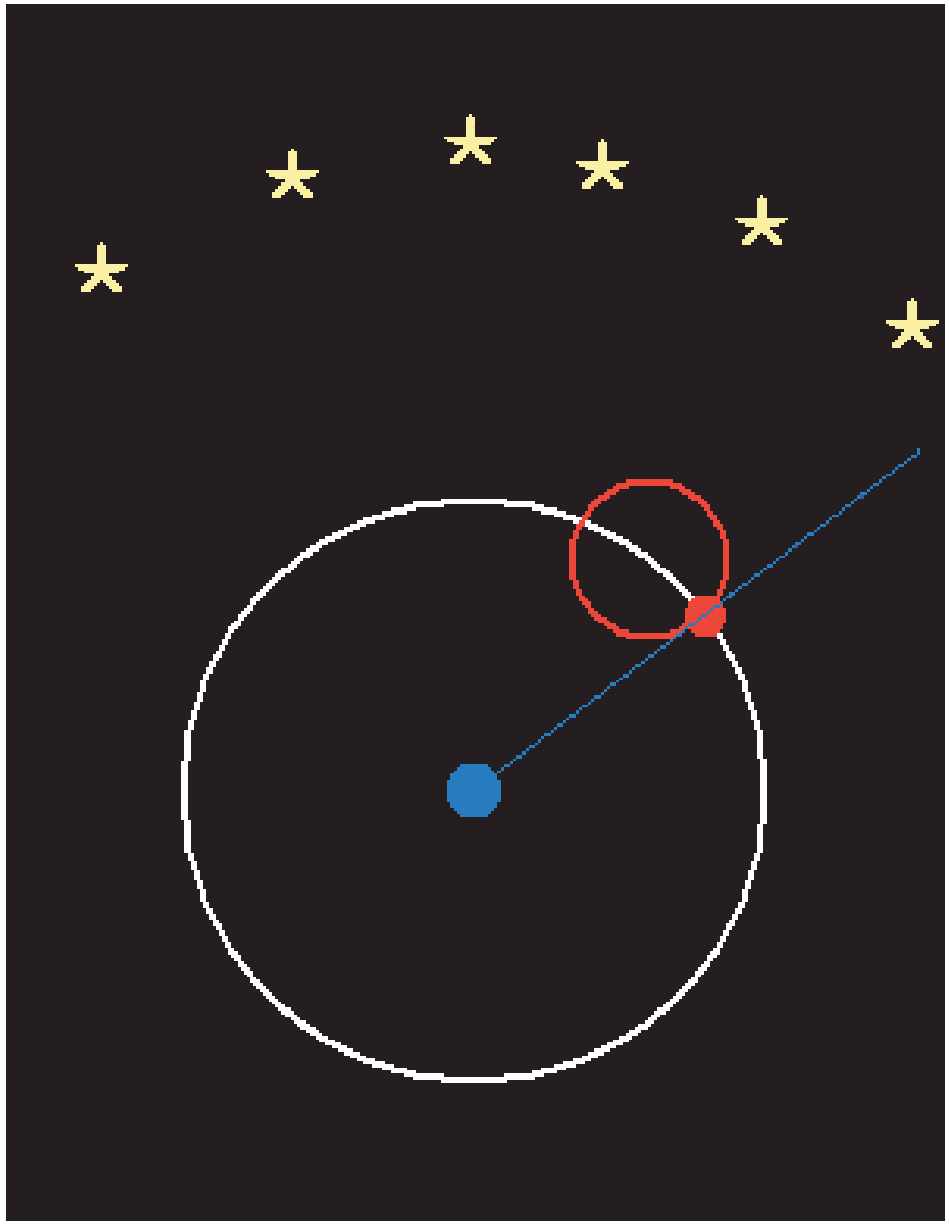
Ptolemaic system

- Geocentric
- Nice circular motion



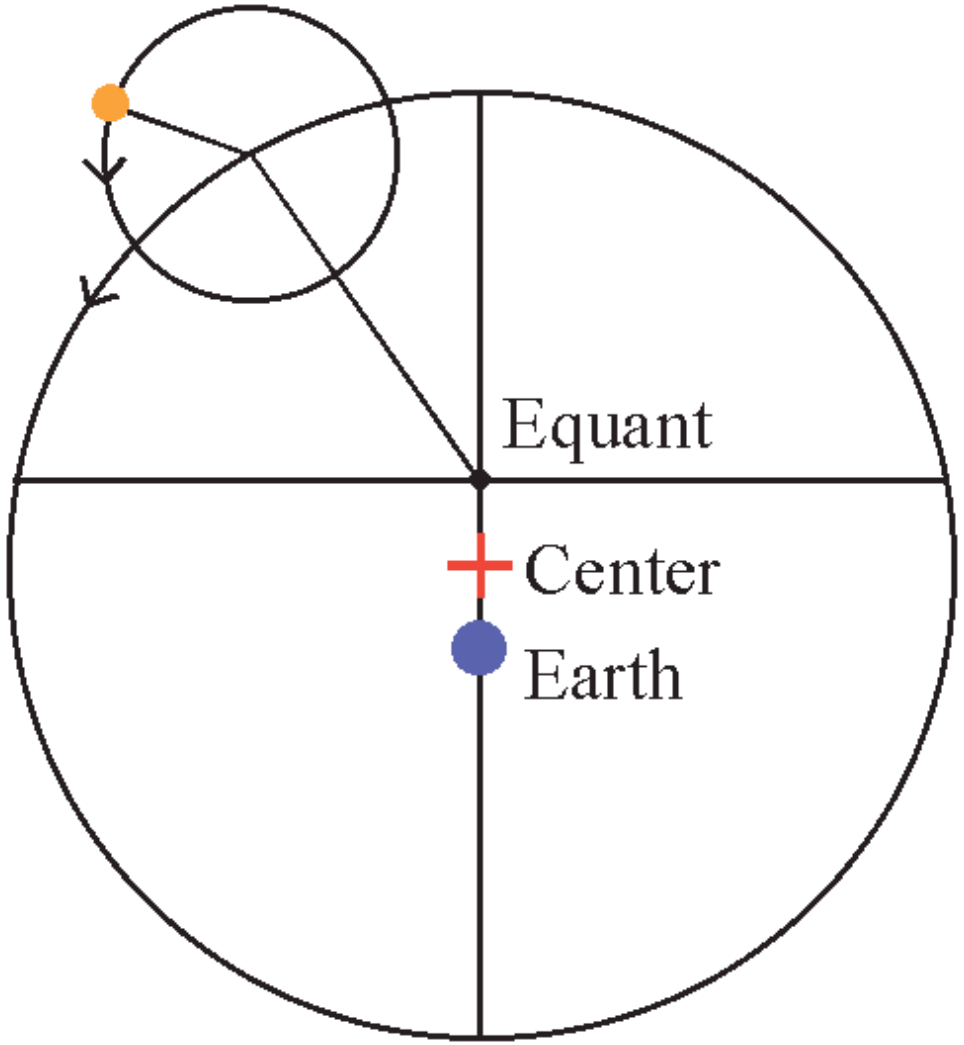
Ptolemaic system

Yes, it can explain retrograde motions



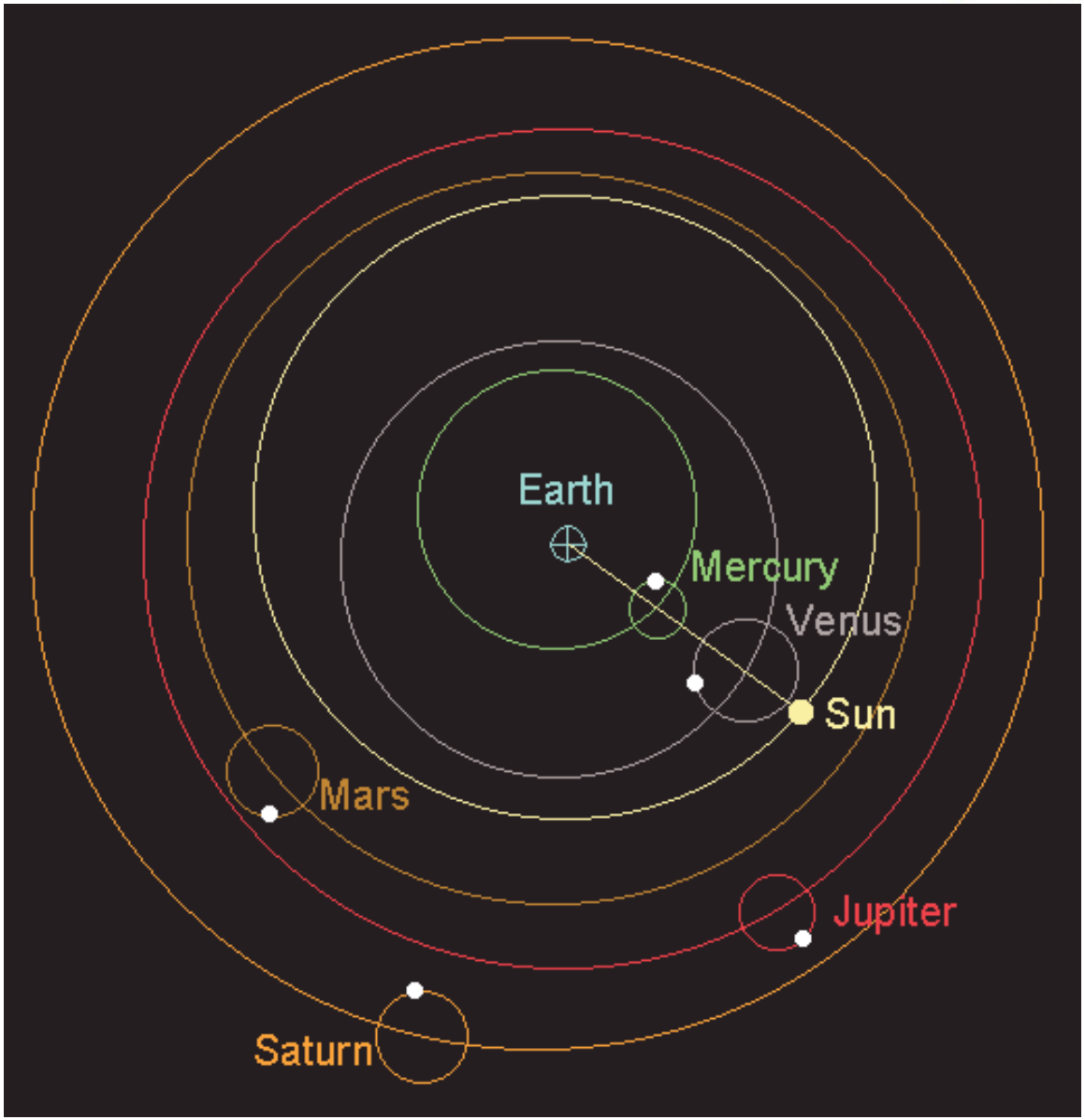
Ptolemaic system

Had to be made more complicated to account for some observations



Ptolemaic system

Overall system of the Solar System.



Ptolemy's Geocentric Cosmology:
Is it a Scientific Theory?

Yes! …and an accurate one too

- Data: Sun/moon/star motions
- Tentative Model: circular orbits
- Prediction: uniform motion on sky
- New data: retrograde motion
- Refined model: epicycles--explains data!

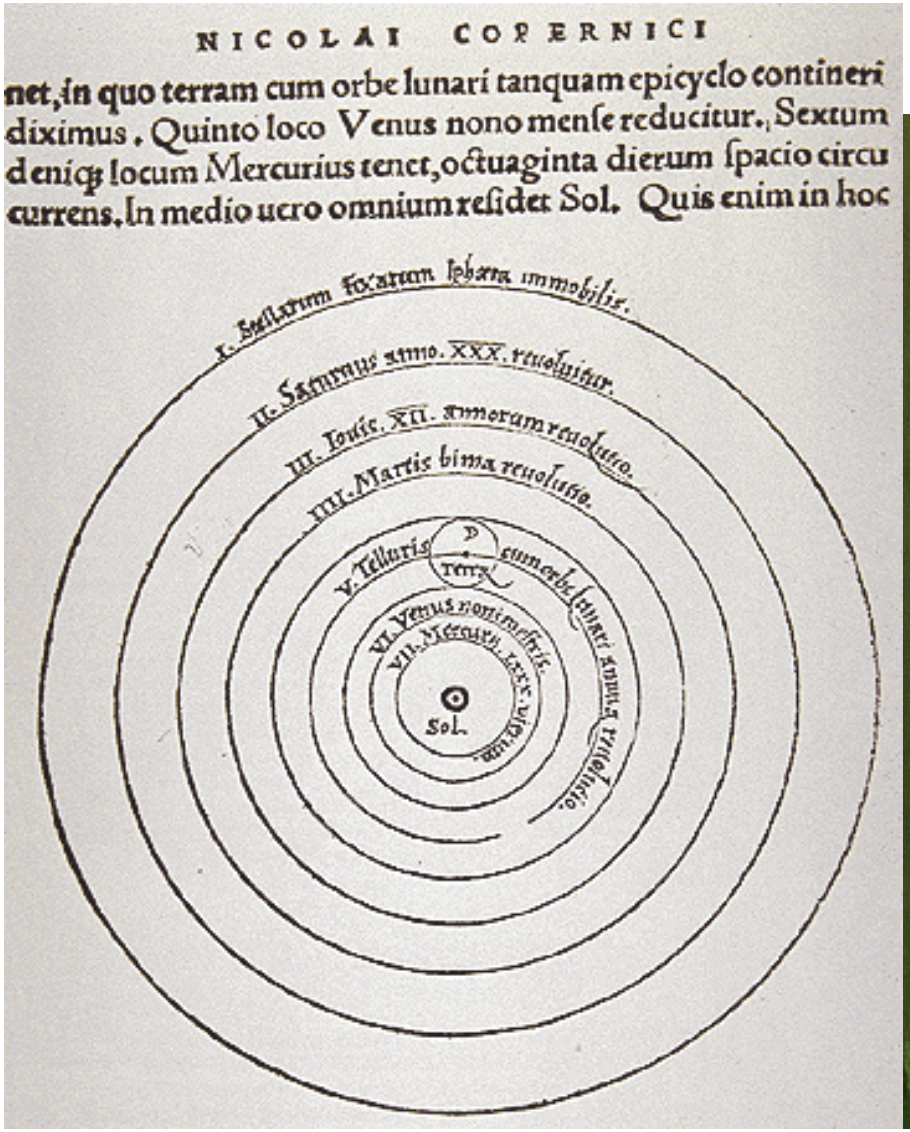
Result: Ptolemaic system (theory)

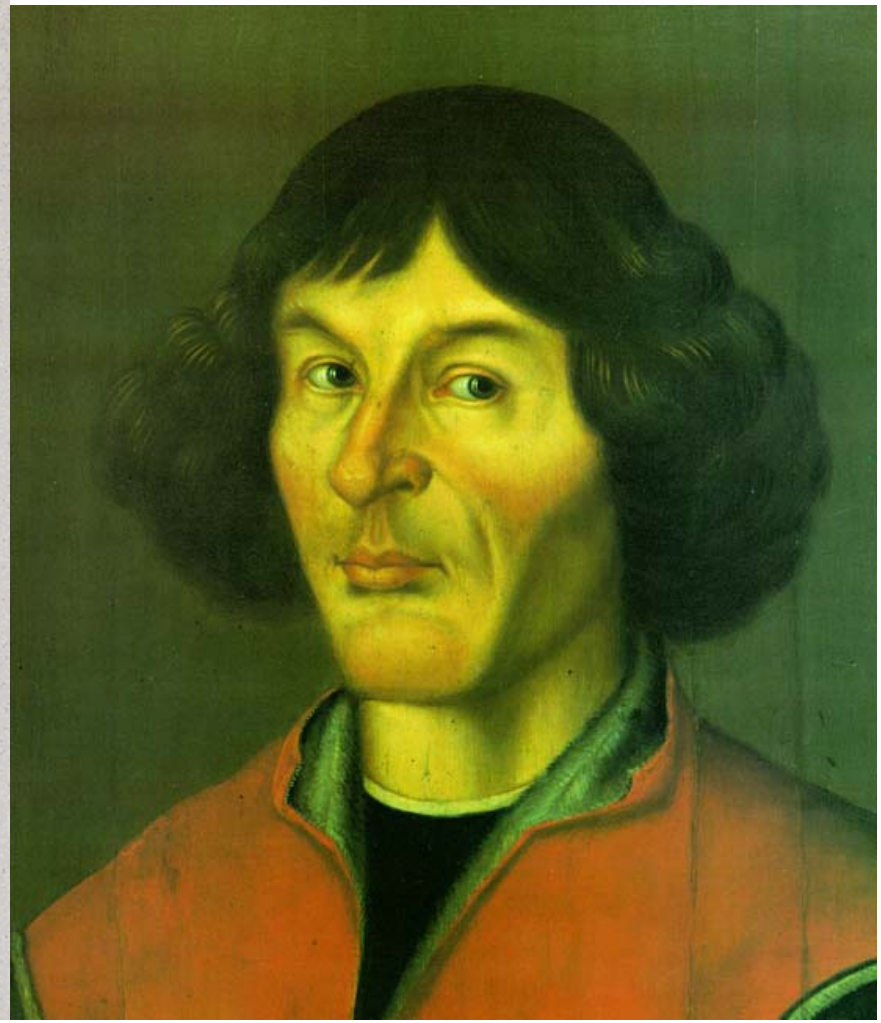
- *strength*: accurate fit of data
- *weakness*: predictions for new data?

More Ptolemaic Problems

- Each planet acted independently of others
- There was no universal rule governing the planets motion
- Nonetheless, for a 1000 years this model ruled western thought
- However, by the late middle-ages astronomers felt that it was too complex, and a search began for a system with simple underlying principles

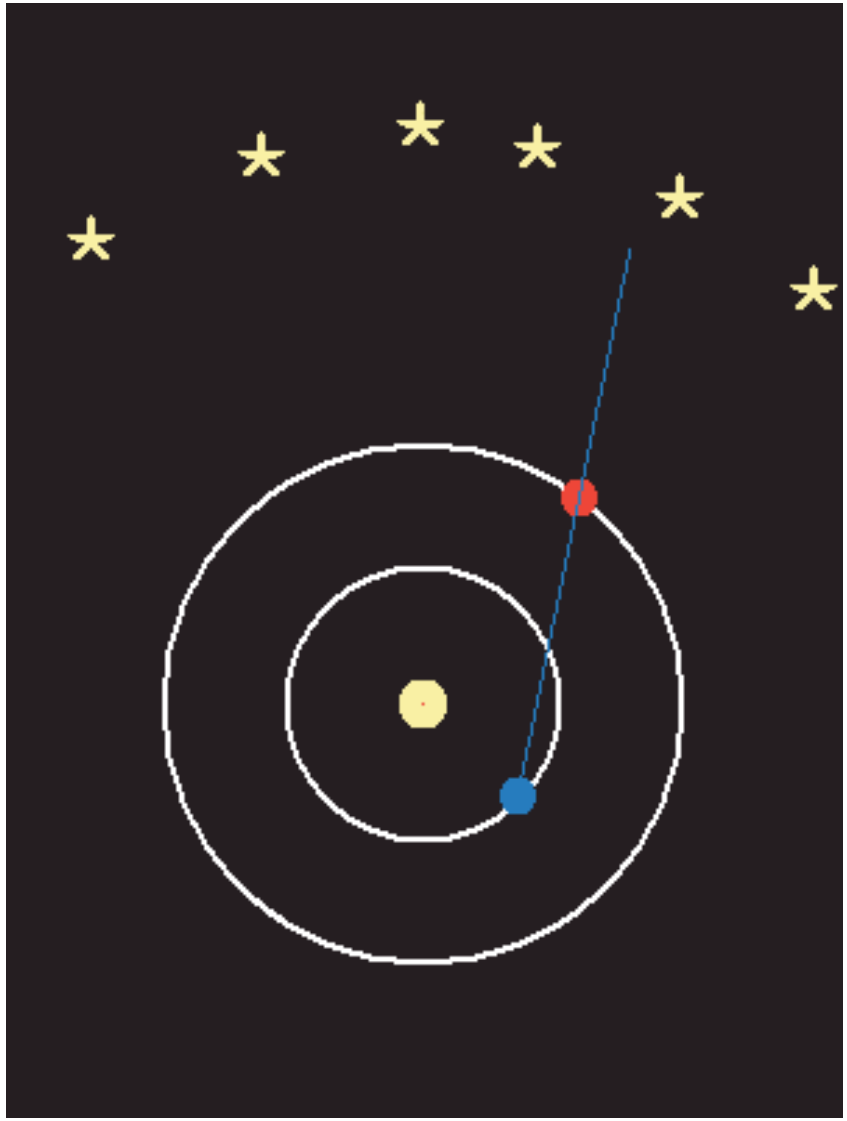
Copernicus (1540) resurrected the heliocentric model





Copernican Theory

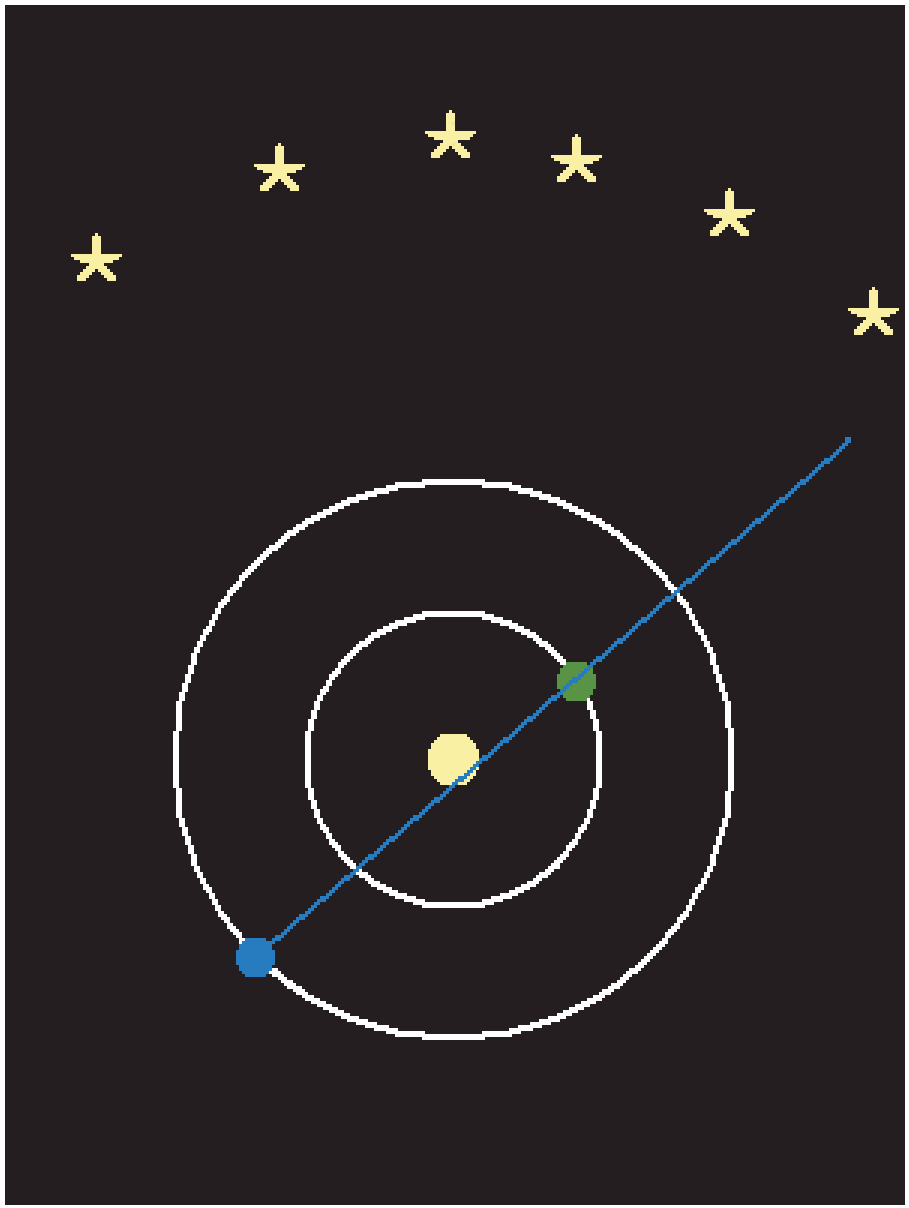
- Can explain retrograde motion
- Much simpler
- Still kept to circular motion
- Eventually changed the way we think of ourselves!



Copernican Theory

http://www.astro.ubc.ca/~scharein/a310/SolSysEx/retro/Retrograde.html

Also Copernicus system naturally works for Venus too

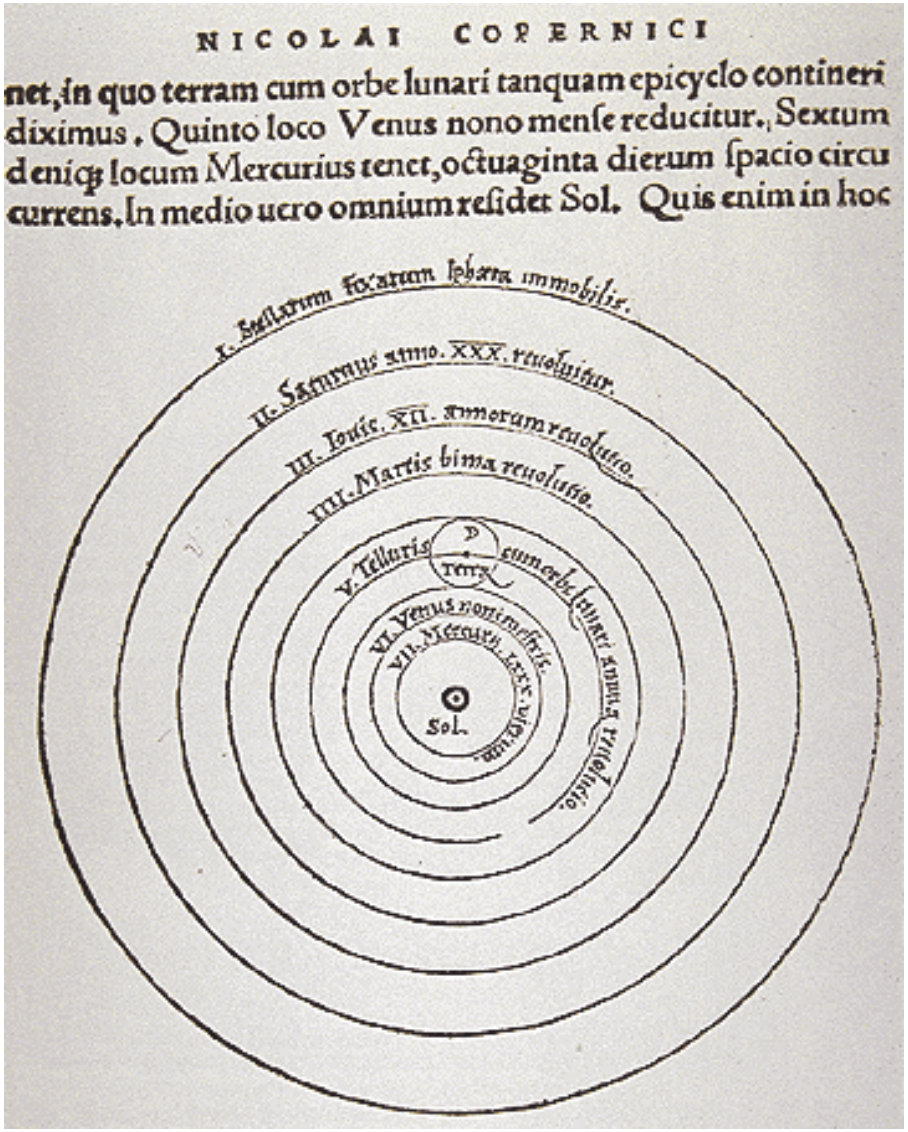


Copernicus (1540) Heliocentric Model

BUT, keep in mind that the geocentric model was still valid. Both models explained the observed motion.

Heliocentric is NOT obvious!

IT was determined a philosophical argument for 50 years! New observations were required to determine which is correct.



Tycho Brahe (1580)

- Spent his life producing a catalog of carefully observed stars and planets using “state-of-the-art” observatory
- No telescopes!
- Yes, had a metal nose, but did not die from burst bladder

Uraniborg

Accurate measurements to about 1 minute of arc (1/15 the diameter of the moon)

Johannes Kepler (1600)

- Tycho's assistant in Prague
- After Tycho's death, succeeded Tycho's position and had access to the excellent data
- How to fit the Heliocentric model to accurate data of Mars?

Johannes Kepler (1600)

There was a problem. The data could not be fit with the heliocentric model if only circles were used.

Then, he began to work with the ellipse.