

Astronomy 210

Section 1– MWF 1500-1550

134 Astronomy Building

This Class (Lecture 4):

Early Cosmology

HW #1 Due on Friday!

**You missed the first
planetarium show.**

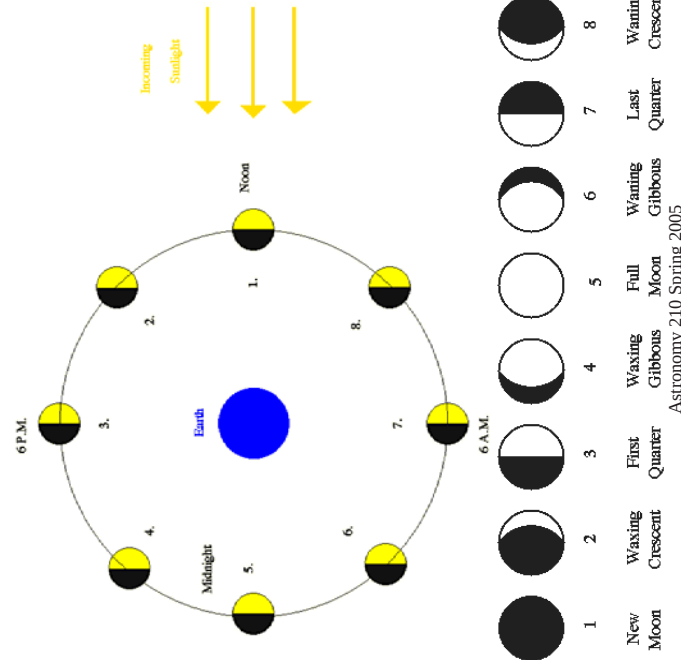
Next Class:

Cosmic Revolution

Music: *Twilight* – Squirrel Nut Zippers

Jan 26, 2005

Astronomy 210 Spring 2005



Jan 26, 2005

Astronomy 210 Spring 2005

Outline

- Lunar Eclipses
- Solar Eclipses
- The Motion of the Planets
- Geocentric vs. Heliocentric system

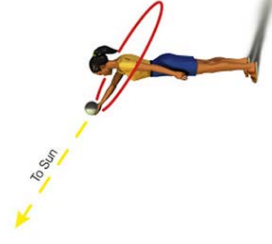
Jan 26, 2005

Astronomy 210 Spring 2005

At Home Phases Demo



- Hold a softball (or equivalent) toward the sun (or a light bulb)
- Spin around, and watch the ball experience phases like the Moon!



<http://www.astro.uiuc.edu/projects/data/MoonPhases/index.html>

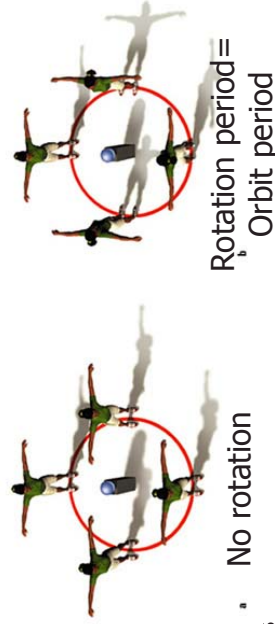
Astronomy 210 Spring 2005

Jan 26, 2005

The Face of the Moon



- Did you notice that we only see one face of the Moon?
- Does this mean the moon doesn't rotate?
- No, the Moon rotates so that the same face is always pointed at the Earth
- A lunar day equals a lunar orbit!



Jan 26, 2005

Jan 26, 2005

Astronomy 210 Spring 2005

Dark Side of the Moon?



Is there really a dark side of the Moon?

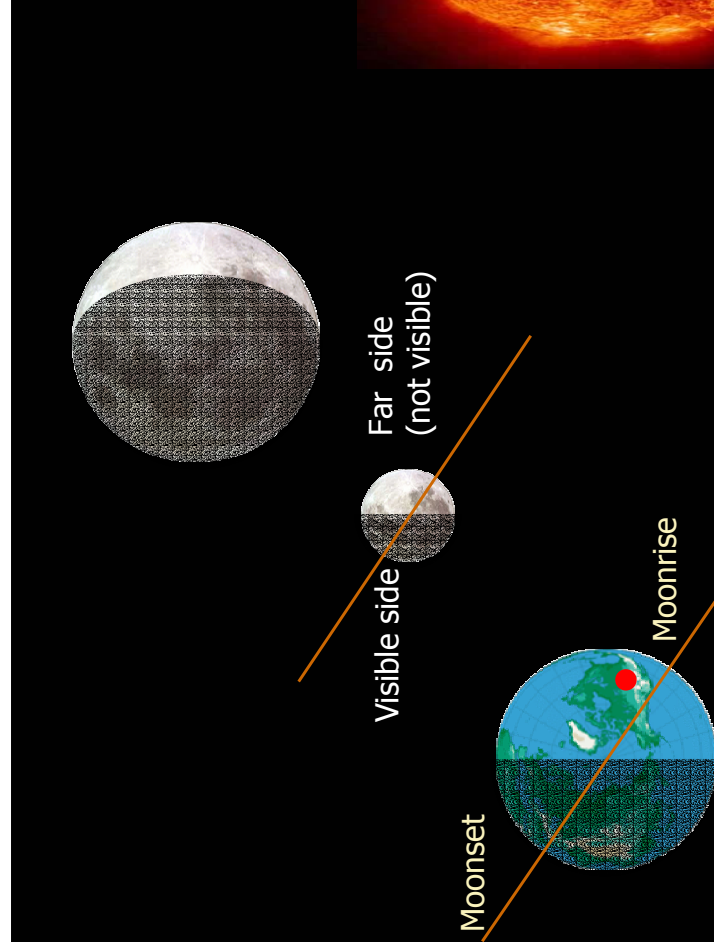
NO! It is better called the Far Side of the Moon.

There is a side we don't see, but during the New Moon phase, it is well lit.

Basically the lunar day is nearly a month long.

Jan 26, 2005

Astronomy 210 Spring 2005



A "Moonth"

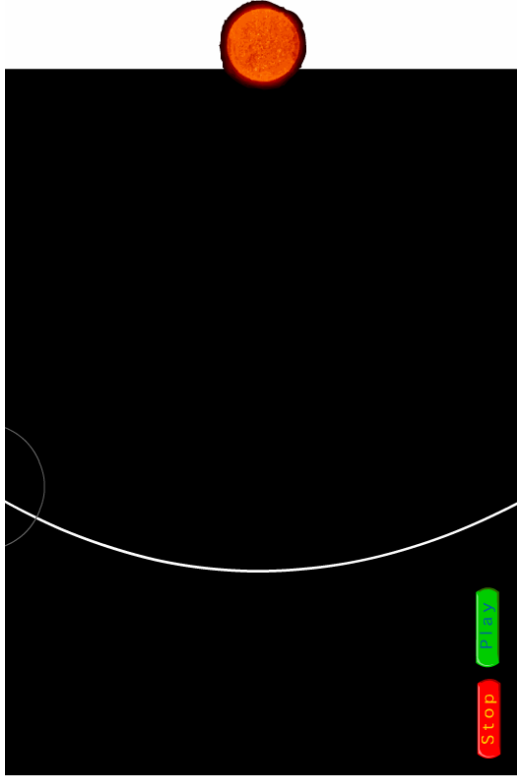


- The month is based on the time it takes the Moon to cycle through its phases
 - 29.5 days – called
- Moon makes one full orbit of the Earth in 27.3 days
 - Called
- Because of the Earth's orbit about the Sun, the Moon travels more than a full orbit each synodic period
 - 360 degrees/27.3 days = 13.2 degrees/day
 - Earth rotates about 15 degrees/hour
 - So Moon rises 13.2/15 hours = 53 minutes later each day

Jan 26, 2005

Astronomy 210 Spring 2005

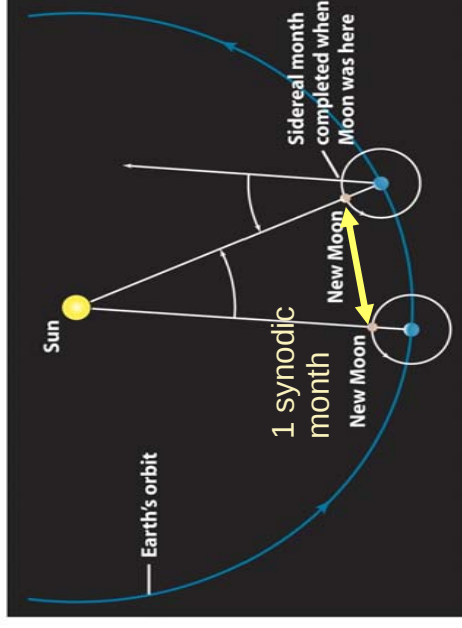
Synodic vs. Sidereal Period



Jan 26, 2005

Astronomy 210 Spring 2005

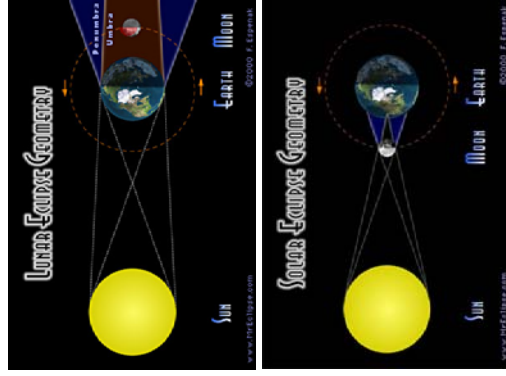
Synodic vs. Sidereal Period



Jan 26, 2005

Astronomy 210 Spring 2005

Basic of Eclipses



- Lunar Eclipse
 - When the Moon passes into the Earth's shadow
 - Sun – Earth – Moon
- Solar Eclipse
 - When the Earth crosses the Moon's shadow
 - Sun – Moon – Earth
- Why don't eclipses happen every full and new moon?

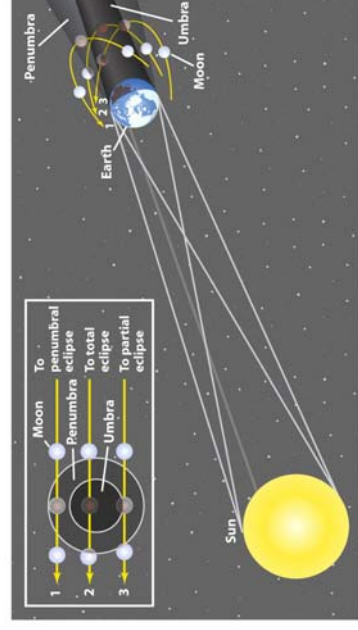
Jan 26, 2005

Astronomy 210 Spring 2005

Lunar Eclipses



- Three types
 - **Total** - The Moon goes completely through the Earth's umbra
 - **Partial** – The Moon only goes partly through the umbra
 - **Penumbral** – The Moon only passes into the penumbra



Umbra?
Penumbra?

Latin for
"complete
shadow" and
"partial
shadow"

Total Lunar Eclipse– Time Lapse



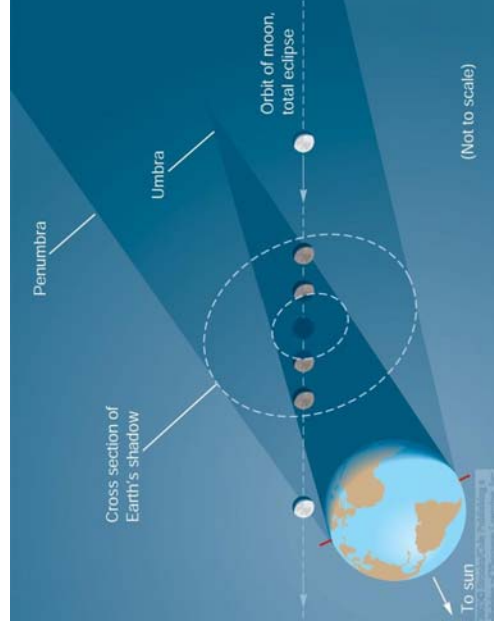
- Occurs when the Moon passes through Earth's umbra completely.



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

Jan 26, 2005
Astronomy 210 Spring 2005
<http://www.mreclipse.com/LEphoto/TLE2001/700sequence1.w.JPG>

Total Lunar Eclipse



Astronomy 210 Spring 2005

Jan 26, 2005

Red Moon



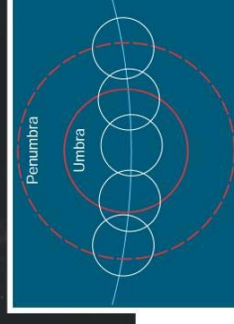
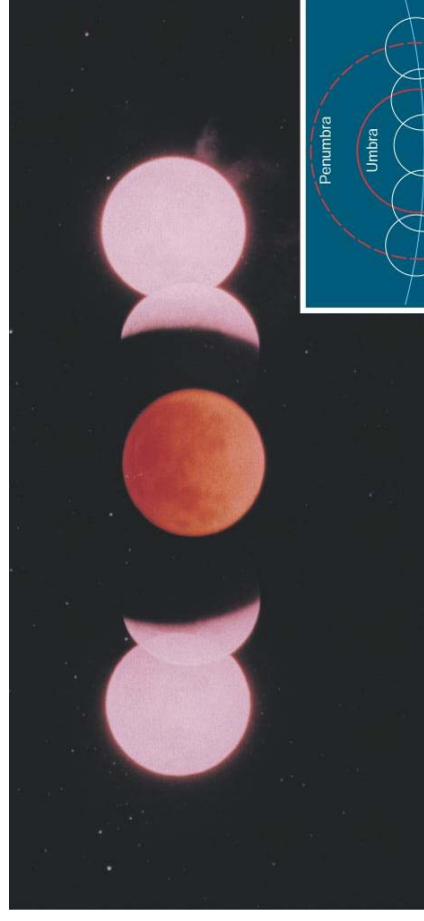
- During a total lunar eclipse, the Moon turns a blood-red/burnt orange color.



- Red color caused by sunlight diffused through the Earth's atmosphere
- Atmosphere scatters blue light away, so Moon is dimly illuminated in red
- The next total eclipse visible in Champaign-Urbana will be in 2007.

Jan 26, 2005
Astronomy 210 Spring 2005

Eclipsed



Color depends on Earth's Atmosphere

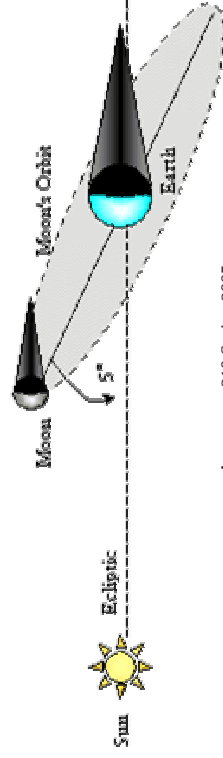
Astronomy 210 Spring 2005

Jan 26, 2005

The Moon's Orbit is Tilted!



- The Moon's orbit is tilted to the ecliptic by 5°
- Just like the Earth's rotation axis is tilted to the ecliptic
- The Moon must be near the ecliptic for an eclipse to occur



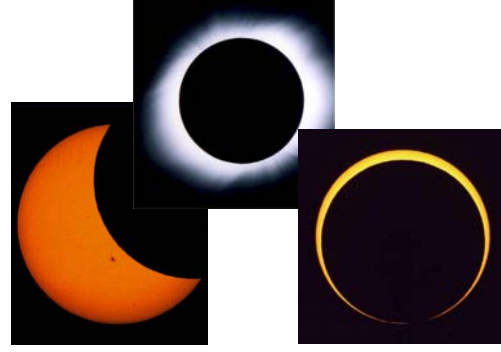
Astronomy 210 Spring 2005

Jan 26, 2005

Solar Eclipses



- Earth passes into the Moon's shadow
- Only occur at the new moon
- Three types
 - **Partial** – when the moon only partially blocks the sun
 - **Total** – when the moon completely blocks the sun
 - **Annular** – when the moon is too small to completely block the sun



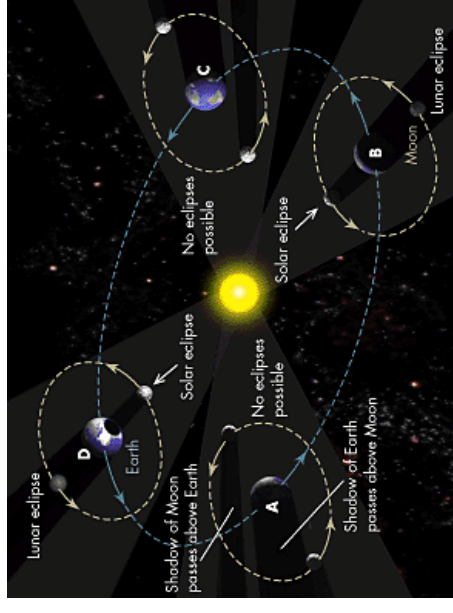
Astronomy 210 Spring 2005

Jan 26, 2005

Eclipse Seasons



Nodes are the two points in each orbit at which the Moon crosses the Earth's orbital plane. For lunar or solar eclipses to occur the nodes must be aligned with the Earth and the Sun. Hence, eclipses can occur only twice per year and these epochs are called eclipse seasons.



Astronomy 210 Spring 2005

Jan 26, 2005

<http://www.ociw.edu/~mhahmy/moon.html>

Solar Eclipses



- Moon casts a shadow on the Earth.
- Only possible because the Moon and Sun are approximately the same size as seen from Earth, around 1/2 a degree.
- Occur roughly twice a year, and last only a matter of minutes.
- The Moon's shadow can't completely cover the Earth, so Viewable only in a very small band of area across the Earth (about 270 km in width).



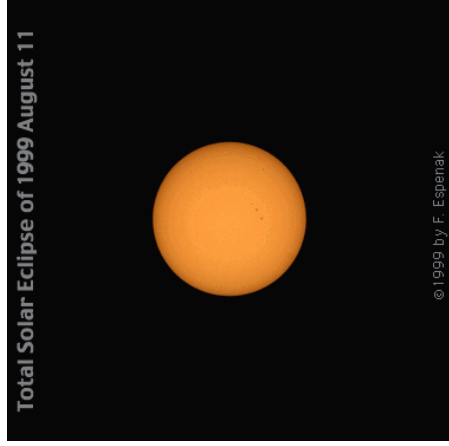
Astronomy 210 Spring 2005

Jan 26, 2005

Total Solar Eclipses



- If you are within the Moon's umbra, you will see a total solar eclipse
- As the Moon covers the Sun, light shines through lunar valleys, creating a "diamond ring" effect
- At totality, we can see the *corona*, a halo of very hot gas around the Sun



Jan 26, 2005

Astronomy 210 Spring 2005

An Eclipse Movie



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

Are they nuts?

Jan 26, 2005

Astronomy 210 Spring 2005

Digitally Added Picture



Jan 26, 2005

Astronomy 210 Spring 2005

http://antwrp.gsfc.nasa.gov/apod/image/9909/corona09_espenak.jpg

Annular Eclipse



- When the Moon is farthest from the Earth, it is too small in the sky to completely cover the Sun
- This results in an ring of sunlight around the Moon



Jan 26, 2005

Astronomy 210 Spring 2005

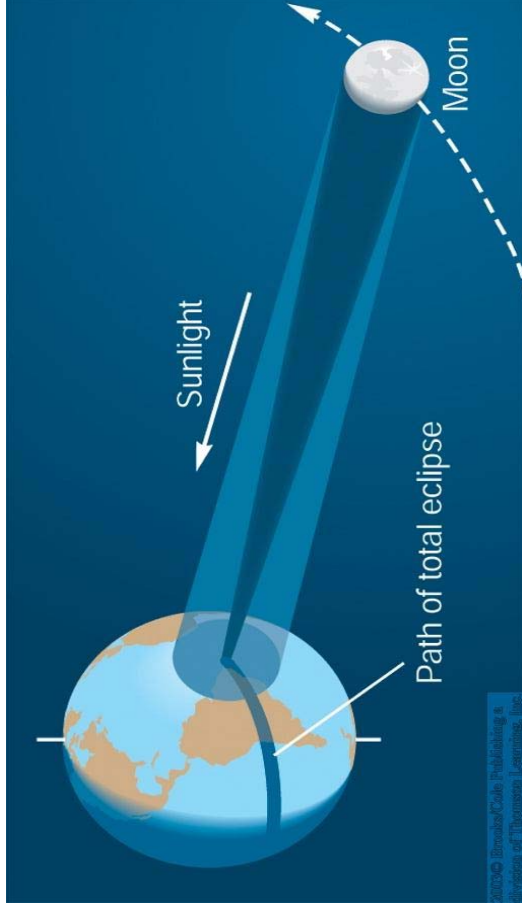
More on the Lunar Orbit

- The Moon's orbit around the Earth not a perfect circle
 - Distance from the Earth to the Moon varies by 10%
- This makes a noticeable difference in the



Jan 26, 2005

Total vs. Partial Solar Eclipses

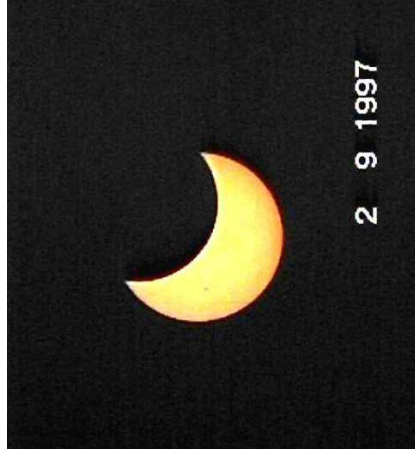


Astronomy 210 Spring 2005

Jan 26, 2005

Partial Eclipse

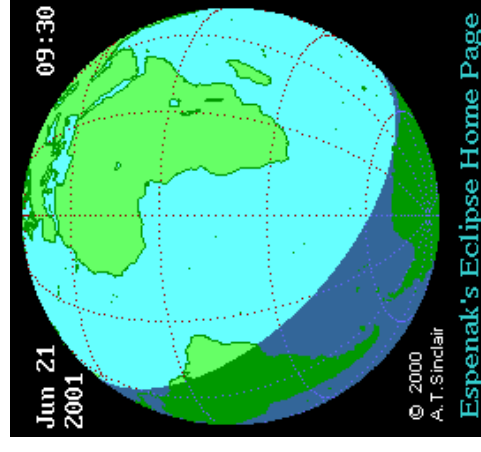
- Like the Earth's shadow, the Moon's shadow has an *umbra* and a *penumbra*
- If you are in the penumbra, you only see a partial eclipse
- Even if people a few miles away see a total eclipse!



Jan 26, 2005

http://antwip.gsfc.nasa.gov/apod/image/9709/solareclipse1_staiger_big.jpg
Astronomy 210 Spring 2005

Path of the Eclipse



Shadow of the Moon races across globe.

Astronomy 210 Spring 2005

Jan 26, 2005

<http://sunearth.gsfc.nasa.gov/eclipse/TS/E2001/T01/annote.html>

Solar Eclipse Seen from Space



Jan 26, 2005

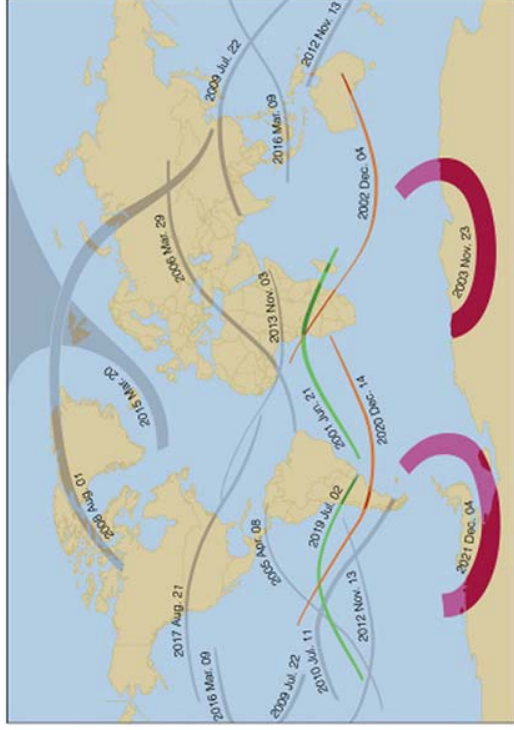
Astronomy 210 Spring 2005

<http://antwip.gsfc.nasa.gov/apod/ap990820.html>

Group Activity:



Which Solar Eclipse Would You Like to Witness?



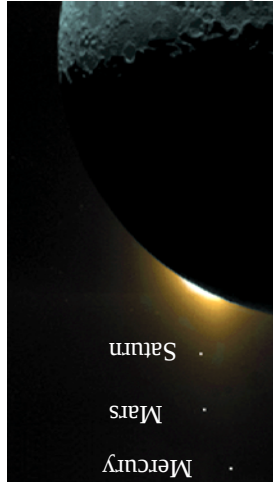
Jan 26, 2005

Astronomy 210 Spring 2005

The Planets



- In ancient times, people noted five bright “stars” that moved through the constellations of the Zodiac over time
- These “stars” were called *planets*, from Greek for “wanderers”



ring 2005

<http://antwip.gsfc.nasa.gov/apod/ap990325.html>
<http://antwip.gsfc.nasa.gov/apod/ap001014.html>

Inferior vs. Superior Planets



- Venus and Mercury are always found close to the Sun
 - Venus is always within 46° of the Sun
 - Mercury is always within 22° of the Sun
 - Referred to as the *inferior planets*
- Mars, Jupiter, and Saturn are not “tied to the Sun” in the sky
 - Can be opposite the Sun in the sky (opposition)
 - Referred to as the *superior planets*

Jan 26, 2005

Astronomy 210 Spring 2005

Names of the Planets



- Planets were given the names of Roman/Greek gods
 - Mercury (Hermes) – Messenger God (fast!)
 - Venus (Aphrodite) – Goddess of Beauty (brilliant!)
 - Mars (Ares) – God of War (red!)
 - Jupiter (Zeus) – King of the Gods
 - Saturn (Cronus) – Father of Zeus
- In Latin languages, the planet names correspond to days of the week
 - Tuesday – Mars, Wednesday – Mercury, Thursday – Jupiter, Friday – Venus, Saturday – Saturn
 - In English, Tuesday-Friday are Nordic in origin

Jan 26, 2005

Astronomy 210 Spring 2005

Planetary Motion

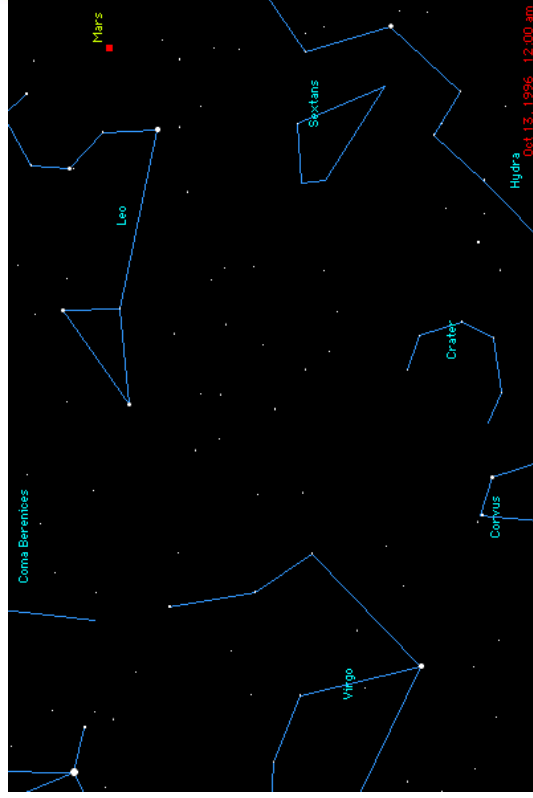


- On a single night, planets will rise with stars and move from east to west.
- This is due to the diurnal motion of the Earth's rotation.
- However, over time, how does planet motion map on the sky?

Jan 26, 2005

Astronomy 210 Spring 2005

Mars Moves



Jan 26, 2005

Astronomy 210 Spring 2005

Planetary Motion

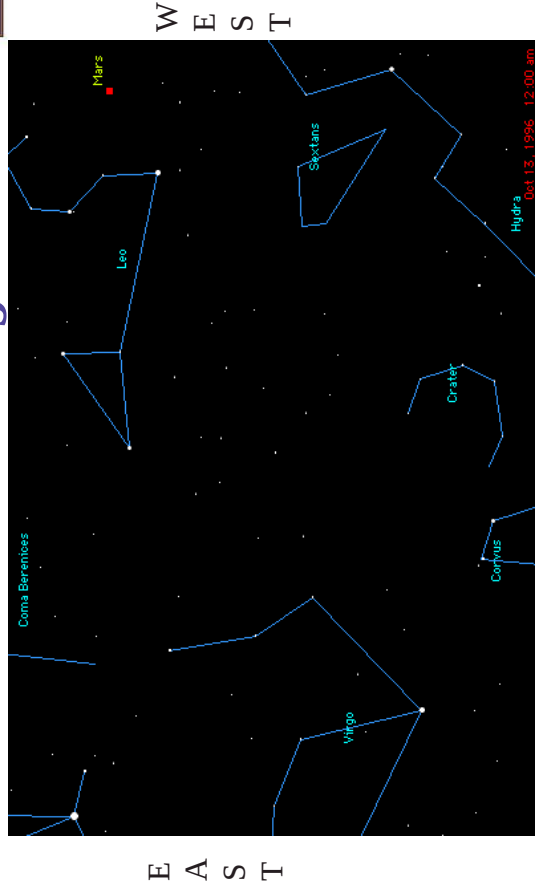


- Over many nights, planets can be seen to move west to east with respect to the stars
 - Also called **prograde** motion
- Each planet moves at a different speed with respect to the stars
 - Mercury is the fastest, then, in order: Venus, Mars, Jupiter, Saturn
- Planets remain within the constellations of the Zodiac, close to the ecliptic

Jan 26, 2005

Astronomy 210 Spring 2005

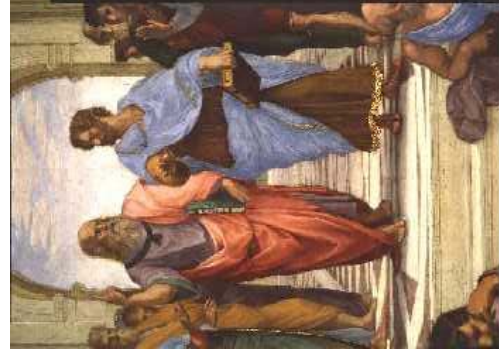
Let's see that again



Jan 26, 2005

Astronomy 210 Spring 2005

What did the Greeks think of the Planetary Data?

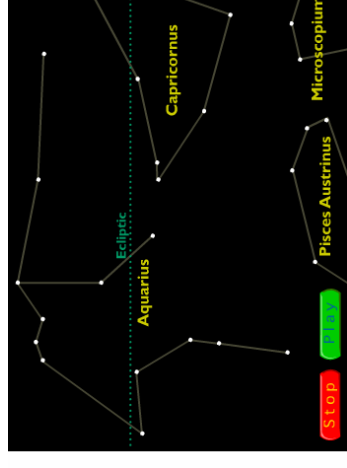


- The Greeks were excellent astronomers
 - Cataloged star positions, brightness
 - systematic, quantitative observations
- They observed that the stars, Sun, and planets appeared to revolve around the Earth

Jan 26, 2005

Astronomy 210 Spring 2005

Retrograde Motion



- Occasionally, a planet's motion (not just Mars) with respect to the stars appears to stop and reverse direction
 - Called **retrograde motion** (east to west)
 - Lasts for several weeks to a few months
 - Remember, this motion is much slower than the diurnal “rise in the east set in the west” motion

Jan 26, 2005

Astronomy 210 Spring 2005

Explaining Planetary Motion



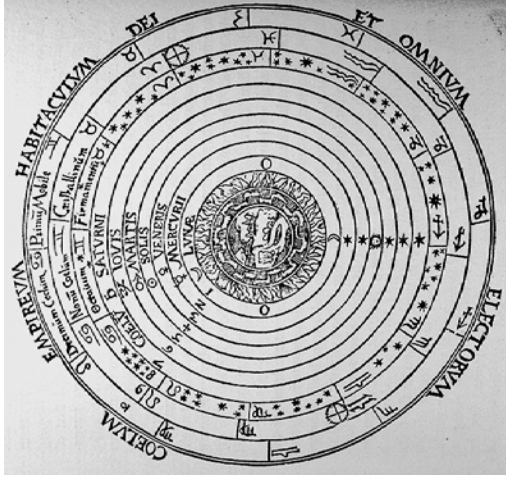
- The Greek philosophers believed that we lived in a **geocentric** (Earth - centered) system
 - The heavens move in perfect circles
 - The celestial sphere is pure and unchanging
- A **heliocentric** (Sun - centered) model had been introduced around 280 BC by Aristarchus, but was rejected
 - The Earth *must* be too heavy to move
- The geocentric system held sway for over 2000 years

Jan 26, 2005

Astronomy 210 Spring 2005

The Geocentric Model

- The basic geocentric model is quite simple
- But how do you explain retrograde motion and the inferior planets?

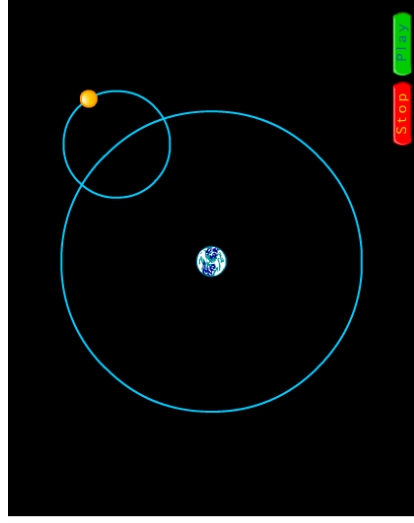


Jan 26, 2005

Astronomy 210 Spring 2005

Ptolemy Explains Retrograde Motion

- Planets move on epicycles, which move along a larger circular orbit
- Ptolemy's system could explain retrograde motion in an Earth-centered system!



Jan 26, 2005

Astronomy 210 Spring 2005

Ptolemy (140 AD)

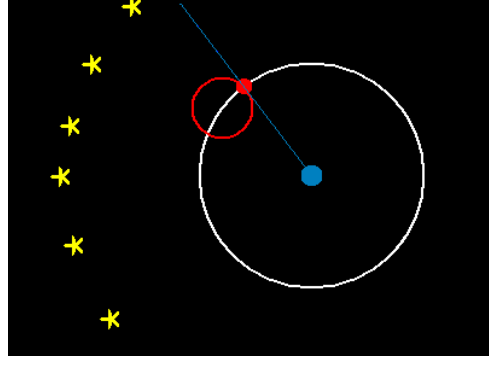
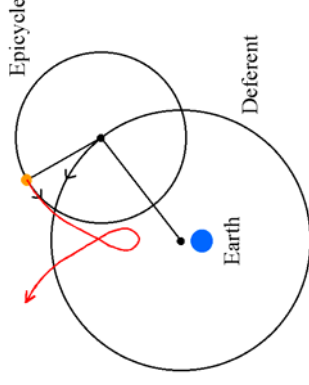
- Created a geocentric model with uniform circular motion that explained retrograde motion and inferior planets
- The Ptolemaic system



Jan 26, 2005

Astronomy 210 Spring 2005

Ptolemy Explains Retrograde Motion



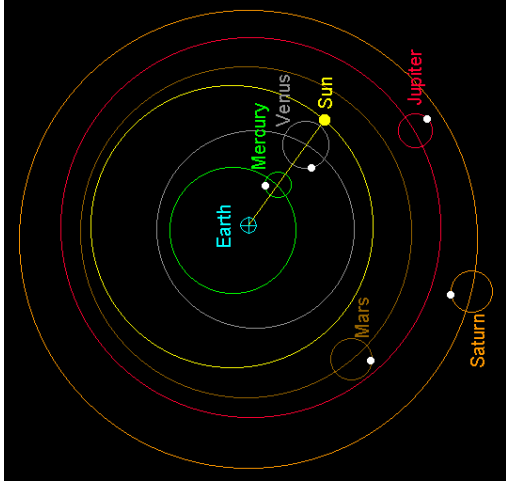
Jan 26, 2005

Astronomy 210 Spring 2005

Ptolemy Explains the Inferior Planets



- Venus' and Mercury's orbits are locked to the Sun
- Ptolemy's model becomes very complex
- Remember *Occam's Razor*...



Jan 26, 2005

Astronomy 210 Spring 2005

Is It A Theory?



- **Yes!**and a reasonably accurate for its time
 - **Data:** Sun/moon/planet motions
 - **Tentative Model:** circular orbits
 - **Prediction:** uniform motion on sky
 - **New data:** retrograde motion, inferior planets
 - **Refined model:** epicycles, Venus & Mercury locked to the Sun
- **Result:** Ptolemaic system (theory)
 - **strength:** reasonably accurate fit of data
 - **weakness:** complex, predictions for new data?

Jan 26, 2005

Astronomy 210 Spring 2005