Announcements

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- **Orchard Hill Observatory Open House**
  
  http://www.astro.umass.edu/%7Erdubois/Observatory/
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- Today’s topic: Motion of Celestial bodies
  - Led to modern science
  - Philosophy: scientific method
  - Discovery of Laws of Motion and Gravity
Phases of the Moon

- Light from the Sun illuminates one half of Moon
- As the Moon orbits, see varying portion of illuminated half
- 29 1/2 day cycle of phases
Rotation of the Moon

If Moon does not rotate...

Can see all faces
Rotation of the Moon

If Moon rotates with Earth...

At all points in the orbit, the red crater is visible from Earth but the blue crater is not.

Can only see one face
Philosophy of science

How science works . . .

- May be many models that describe apparent reality
- Science chooses the one with predictive power
- Predictive power implies *physical laws*
Philosophy of science

How science works . . .

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The Scientific Method

- Theories are subject to revision in light of new data
- Simple theories are preferred to complicated theories without additional predictive power
  *Occam’s Razor*
Distance to Sun

- Aristarchus of Samos — 280 BC
- Heliocentric theory
Models motions of planets

Greek cosmology

- Heliocentric model
Models motions of planets

Greek cosmology
- Heliocentric model
- Geocentric model

Celestial sphere rotates to the west

Stars fixed on celestial sphere
Retrograde motion (1/3)

Planets mean wanderers

Outstanding problem for Greek astronomers and philosophers

Example: path of Mars in 2005-2006
Retrograde motion (2/3)

- Ptolemaic Geocentric Theory (elaborate mechanism)
Retrograde motion (2/3)

Ptolemaic Geocentric Theory (elaborate mechanism)

- Planet moves rapidly eastward along epicycle
- Epicycle moves slowly eastward along deferent

As seen from Earth, planet moves eastward (direct motion)
Retrograde motion (2/3)

Ptolemaic Geocentric Theory (elaborate mechanism)

- The planet moves rapidly westward along an epicycle.
- The epicycle moves slowly eastward along the deferent.

As seen from Earth, the planet moves westward (retrograde motion).
Retrograde motion (3/3)

- Copernican Heliocentric Theory
- Simple explanation (Demo)
Distance to planets

- **Copernicus—1500 AD**
- **Revival of heliocentric theory**
Successes of Copernicus (1/2)

- Explained retrograde motion
- Explained *inferior* and *superior* planets
- Found a relationship between the orbital period and the distance of a planet from the Sun
Distances to planets inferred by Copernicus

<table>
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<tr>
<th>Planet</th>
<th>Copernican value (AU*)</th>
<th>Modern value (AU)</th>
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<tr>
<td>Mercury</td>
<td>0.38</td>
<td>0.39</td>
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<tr>
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Successes of Copernicus (2/2)

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- Remarkably accurate by today’s standards
- Outer planets not yet discovered
Distances to planets inferred by Copernicus

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Successes of Copernicus (2/2)

Distances to planets inferred by Copernicus

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Galileo (1/2)

Galileo Galilei (1564-1642)

- Telescope invented by Dutch optician in 1600s
- First to use telescope for astronomical observations
- Observed phases of Venus
- Discovered moons of Jupiter
- Tried to understand general laws of Nature
Phases of Venus (1/3)

- Venus has phases, just like the Moon
- Full Venus is behind the Sun
Phases of Venus (2/3)
Phases of Venus (3/3)

- Venus’ deferent must revolve at the same rate as Sun’s deferent.
- Earth observer would never see Venus more than half illuminated.
- Inconsistent with Galileo’s observations.
- Ptolemaic model must be wrong!
Moons of Jupiter

Jupiter has four moons easily seen with a telescope.

Appear to move back and forth relative to Jupiter.
Moons of Jupiter

- Jupiter has four moons easily seen with a telescope
- Appear to move back and forth relative to Jupiter
- Largest orbit takes longest
- Miniature Copernican solar system
THE STARRY MESSENGER
Revealing great, unusual, and remarkable spectacles, opening these to the consideration of every man, and especially of philosophers and astronomers
AS OBSERVED BY GALILEO GALILEI
Gentleman of Florence, Professor of Mathematics in the University of Padua,
WITH THE AID OF A SPYGLASS lately invented by him, in the surface of the Moon, in innumerable Fixed Stars, in Nebulae, and above all in FOUR PLANETS swiftly revolving about Jupiter at differing distances and periods, and known to no one before the Author recently perceived them and decided that they should be named
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Venice, 1610
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